THE INDUSTRIAL FRONT

DEPARTMENT OF MUNITIONS
AND SUPPLY

Honourable C. D. Howe, Minister

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FOREWORD

This volume tells the story of the industrial war effort of Canada up to the end of 1943, the year in which the production of arms reached its peak. It serves, also, to record the work of the Department of Munitions and Supply, the instrument created by the people of Canada to attain an industrial production unparalleled in their history.

Those who read this record will learn little of the toil and problems involved, but they will learn the industrial achievements of Canadians in 1,500 days of war. And from these pages, too, they may glimpse something of what Canada can and will become when the war clouds pass away.

C. D. HOWE,
Minister of Munitions and Supply.

January 1, 1944

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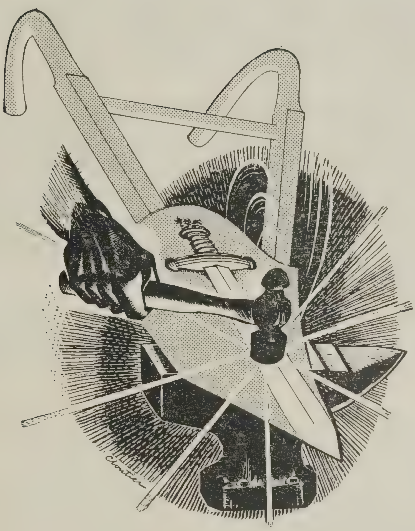


INTRODUCTION

IN THE rugged history of Canadian toil and achievement the year 1943 towers like a mountain peak. In this year, to a degree never before known in the record of the nation, Canada was mobilized in one common cause.

Her men and women served on many battlefronts. The sailor faced the icy scud and spindrift of the North Atlantic and the Alaskan Gulf. The airman flew high and fast over lonely seas and nameless mountains, over deserts and jungles, over the checkerboard terrain of occupied Europe and into the screaming flak above the battered cities of the Axis. The soldier brushed the skirts of death in Sicilian dust and in the autumn rains of the Italian hills.

In Great Britain thousands of Canadians manned the island bastions and made ready for battles yet to come. At home from the grey shores of Labrador to the green slopes of the Pacific, more thousands served in the army camps, the air stations, the training ships, and administrative offices of the greatest military organization the Dominion had ever known.

And back of them served another army, an army more than a million strong, an army of men and women young and old—the army of the industrial front.

Their uniforms were smocks and overalls, their insignia the numbered badges of the war plants. Their weapons were calipers and gauges, pencils and typewriters, picks and shovels, hammers and axes, pneumatic drills and welding torches. Their campaigns were fought in the murk of factory smoke and the fantastic glare of furnace hearths, in the swift bustle of the office and in the pregnant silence of the laboratory, in the caverns beneath the earth and in the shipyards by the sea. Their battle sounds were the clatter of rivetting guns, the humming of turbines, the screech of saws, the roaring of mine skips, the clangorous din of shops and foundries, the rhythmic pounding of great machines.

This was the army that mined the ore and felled the timber and harnessed the waters, shaped the steel and drew the brass, built the ships and fabricated the planes, made the guns and ammunition, swung the trucks and carriers down the assembly line. These were the men and women who mastered the craft of Krupp and Vickers in a country that had never made a modern gun. These were the workers who rivetted the plates of naval

craft in yards that had never sent a fighting ship to sea. These were the people who concentrated with delicate accuracy upon the tiny valves and wires of devices so novel in creation and so secret in their magic that their very names were familiar only to the few. These were the folk from shop and farm who mastered the alchemy of explosives hitherto unknown, in the great shell-filling plants where death was locked in a drop of liquid, annihilation lay imprisoned in a pinch of powder.

There was a place and need for every strength and skill, for the generalship of shrewd brains, for the power of brawny shoulders and the craft of nimble fingers. There was a place and need for every pound of metal, every foot of timber, every unit of waterpower, every tool, every machine, and every factory that could be adapted to the manufacture of munitions and supplies of war. Almost every human and material resource of a Dominion that had found its strength for the first time was drawn and blended into production on a gigantic scale.

It had taken four years. There was 1940—a year of plans and small beginnings, with the first trickle of war supplies from the few sources immediately available in a land tuned to the arts of peace. There was 1941—a year of construction, of conversion and expansion, of vastly broadened plans, and of quickened output in answer to the darkening urgencies of the time. There was 1942—a year of rising production, a year of objectives reached and passed in the face of perils, problems, and confusions. And then in 1943 a year of output so heavy that the industrial capacity and the national economy groaned beneath the stress and strain, a year that ended with Canadian employment at an all-time high, a year that saw shifts and changes in the production flood—a turbulence of the waters in response to the altered tide of war.

Fourth in production achievement of all the United Nations, the Dominion had set up a mighty record of output. In volume it was overshadowed, naturally enough, by the United States, Russia, and the United

Kingdom; but in timeliness, variety, and quality it constituted a major factor in the Allied swing from desperate defence to victorious attack.

From Canadian shipyards had come 232 cargo vessels and 356 armored naval craft. From Canadian aircraft plants had come nearly 11,000 planes. From automotive plants had come some 560,000 units of mechanical transport and more than 31,000 armored fighting vehicles. From the small arms factories came nearly one million machine guns and small arms units. From the gun shops came 83,000 units, including Army and Navy guns, barrels, carriages, and mountings. From Canadian arsenals and shell-filling plants came 59 million rounds of heavy ammunition and three billion rounds of small arms ammunition. From the chemicals and explosives industry came an output of one million tons. From the signals, instruments and communications industry came $282 million worth of supplies. From general manufacturing had come millions of dollars worth of stores and furnishings for military establishments, millions of dollars worth of personal equipment for the services. More than $1.38 billion had been spent on construction. Steel production had increased to three million tons a year, double the peacetime output. The aggregate refined production of copper, nickel, lead, and zinc had risen 20 per cent over 1939 output. Power installations produced a total of 10 million horsepower, an increase of about 21 per cent over 1939. Aluminum output was greater than the peacetime production of the entire world.

Behind these cold figures lies the story of an industrial evolution of vast potential effect upon the destiny of the Dominion. For by this prodigious effort the nation learned its own strength while serving its own freedom. The figures, imposing enough in bulk, merely suggest the magnitude of the achievement.

It is no simple task to convert and expand a country's industrial capacity from the relatively simple needs of peace to the specialized and ever-changing demands of war. The worker who makes refrigerators must learn new skills if he is to make machine guns. The factory that turns out bicycles must have new machinery if it is

to produce aircraft parts. And when the worker is trained and the plant equipped there is no guarantee that the acquired skills or special capacity will fit into the changing pattern of production to the end of the war. Had that been the case, had mere volume been the objective, the figures would have been even more imposing.

War, however, is never static. No war production plan can achieve ultimate balance and standardization. The secret weapon of today is the obsolete weapon of tomorrow. The guns of defence are not the guns of attack. A munitions program aims at its own dissolution and it is subject to subtractions and additions, to expansions and contractions, in direct relation to its own success.

The munitions and war stores that poured from Canada's industrial front at the production peak in 1943 differed widely in variety and kind from the equipment produced in 1940. Weapons made obsolete by improvements in the enemy's defensive armament, such as the Boys anti-tank rifle, had been cut from the list. Standard equipment, such as the universal carrier, had undergone scores of improvements as a result of lessons learned in the factory and on the battlefield. Supplies which had accumulated in heavy reserve by reason of the great output achieved were being produced in diminished quantity. Heavier and more difficult assignments, such as production of the Mosquito aircraft, the Lancaster bomber, and a long list of secret devices, had been given to Canada on the basis of the nation's newly proven capacity.

The production figures take on new meaning, therefore, when it is realized that they were achieved not as the climax of an uninterrupted and steadily increasing flow, but as the peak of an output achieved in the face of constant changes which, in turn, were complicated by shortages of materials, tools, and skilled labor.

Shifts of emphasis, forecast early in 1943, altered many aspects of the program during the latter half of the year. Inasmuch as less than 30 per cent of Canada's

war production goes to her own armed services and the remaining 70 per cent goes to other members of the United Nations, the greater part of the Dominion's munitions output is directly dependent on requirements from abroad. Originally those demands reflected Great Britain's desperate need of war stores to replace the equipment lost at Dunkirk. Later they reflected the defensive needs of the armies in North Africa, the defensive needs of Russia and China, the defensive requirements of naval warfare, the insatiable demands for replacement of equipment lost at sea.

Still later they reflected the changing course of the war in the demand for new types of weapons and supplies for Allied armies on the attack, in United States requirements for munitions and raw materials to supplement her own great production program, in the demand for even heavier tonnages of escort and cargo shipping as the pace of the offensive accelerated. And so in the waning months of 1943 the very slackening of orders for many types of Canadian munitions reflected the improved position of the United Nations on all fronts. Orders for certain types of ground equipment had been cancelled or sharply reduced, although standard weapons such as army rifles and Bren guns were still in heavy demand, and small arms ammunition for these weapons continued to pour from the machines. Naval shipbuilding, and the production of aircraft, motor transport, and signals and communications equipment headed the list, but there were signs of downward adjustments in other programs.

Despite the levelling off in contracts toward the close of the year, in 1943 Canada attained the highest level of production in her history, a level that was more than two and a half times that of pre-war years. Aircraft output increased from 3,781 planes in 1942 to 4,133 in 1943—a rise of over nine per cent. Yet more intricate planes were produced, and consequently their value in 1943 was 50 per cent higher than in 1942.

The armored fighting vehicles produced during 1943 numbered 15,500 as against 12,500 in 1942, a 24 per cent increase. The value of this production likewise increased. It rose by 44 per cent, owing to the newer and more costly types of equipment produced.

Mechanical transport production dropped from 192,000 units in 1942 to 175,000 units in 1943. As with the fighting vehicles, the mechanical transport produced was of more intricate and costly type; for example, a larger proportion of 4-wheel drive vehicles was included, and so the value of mechanical transport output went up by 19 per cent.

Production of gun barrels, carriages, and mountings, figured as separate units, totalled 45,000 in 1943, as compared with 31,000 in 1942. The output of machine guns, rifles and other small arms jumped from 325,000 in 1942 to 580,000 in 1943.

Of heavy ammunition, 30 million rounds were produced in 1943, as against 28 million rounds in 1942. Small arms ammunition jumped from 1.2 billion to 1.5 billion rounds.

The total net production of chemicals and explosives in 1942 was 860 million pounds. This increased to one billion pounds in 1943.

The 1943 production of cargo ships was 150 as against 81 in 1942. Deadweight tonnage jumped from 838,000 in 1942 to 1,478,000 in 1943. Naval production dropped from 117 ships in 1942 to 100 in 1943. But in this sphere, also, production was of a more intricate and costly nature. Frigates were replacing corvettes. Thus total expenditures for new cargo and naval vessels and for ship repairs increased from $256 million in 1942 to $416 million in 1943.

The production of signals and communication equipment and instruments more than doubled that of 1942, when $84 million was spent. The 1943 total was $180 million.

The expenditures on construction projects declined from $219 million in 1942 to $194 million in 1943.

These figures give no adequate picture of the actuality. They merely suggest the industrial achievements of Canada at the height of war production. The delivery of a merchant ship is represented by a mere figure in a tabulation, "Cargo Vessels Completed," but behind the statistics lies a wide, colorful segment of Canada's industrial life.

For every yard building ships on the Pacific Coast, on the Great Lakes, on the St. Lawrence, or on the Atlantic seaboard, there are scores of shops and factories in all parts of Canada turning out components and fittings for those ships—components and fittings ranging from marine engines to binnacles.

The bomber that rolls out of the aircraft plant ready for its test flights is much more than the achievement of the aircraft workers. Aluminum sheeting, propellers, radio equipment, electric wiring—the products of a hundred industries—meet on the assembly line.

The plant turning out thousands of rounds of heavy ammunition is merely completing the work of men and women in other factories whence come the fuses and primers, the shells and cartridges, the cordite and T.N.T. Every major production plant, in fact, draws from dozens of contributory sources which could be compared to the cross-threads of a great web, with the various production programs as the main radial threads branching out from a common centre. The smallest thread is an integral part of a complete and intricate structure, firmly knit and held together.

Continuing the analogy, all war production programs radiate from and converge toward the apex of the vast webwork which constitutes Canada's wartime industrial organization. That apex is the Department of Munitions and Supply, which shapes, balances, and unifies the whole structure through two vital elements—direction and co-ordination. Without these elements and without that apex the web would collapse into a tangle of unrelated threads.

The Department of Munitions and Supply is the most important productive and regulative organization in the history of the Dominion. Canada is the only country of the United Nations which handles all war supply through a single agency. The Department lets contracts and allots orders not only for war stores on behalf of the Canadian armed services, but also on behalf of the other United Nations. It has facilitated production by helping to convert and expand peacetime industries, by the construction of new plants and the establishment of entire

new industries under government management, and by controlling raw materials and services so that every available resource of the nation can be channelled into the war program.

All this has demanded a high degree of co-ordination. It has demanded co-ordination within industry, co-ordination within the Department and co-ordination between the Department and all other administrative bodies of Canada's wartime government.

Within the Department, the production program is administered by branches. Problems of supplying raw materials and services to feed the production program are handled by controls. Heads of the various production branches are members of the Production Board, and controllers are members of the Wartime Industries Control Board. A Co-ordinator of Production and a Co-ordinator of Controls keep the respective programs in balance, and an interlocking membership provides co-ordination between the work of the two boards.

Each responsible official has every possible opportunity, therefore, to know what is going on in his own field, not only from the production side but from the control side as well. Neither controllers nor production heads function in airtight and watertight compartments. Each production branch and each control has authority in its specific field but there is a great deal of informal co-ordination.

Most of the work of the Department is done in four large buildings grouped within the space of two city blocks in Ottawa. One building houses the administrative people, two buildings house the production staffs and some controls, another accommodates most of the controls. Because of this proximity, conferences can be held quickly. A production executive can step across the hall, as it were, and get advice or information on a problem relating to services or raw materials or some other branch of production. Expert information on every detail of Canadian industry and the war program is immediately available. Scores of minor problems can be ironed out

with a minimum of confusion. This concentration of key personnel was an important factor in the success of the co-ordinated effort. Equally important has been the fact that almost every Canadian industry has contributed the services of leading executives and specialists for administrative work with the Department. Ranking business men and technicians from every field have contributed their time, abilities, and expert knowledge to the staff work of the Department which constitutes, in effect, General Headquarters of the army of the industrial front.

The production branches are concerned with output. The controls are concerned with regulating supplies of raw materials and services to facilitate that output. It is a common opinion that all the industrial wartime controls are restrictive, because the public is apt to hear more about the restrictive features of their operations.

Actually every control fills two functions—contractive and expansive. Its aim is to restrict the non-essential use of a certain material or service on the one hand, and to increase its production for wartime purposes on the other.

The Steel Controller, for example, restricts the supplies of steel available to civilian industry so that more steel is available for war plants. But that in itself is not enough. So the Steel Controller does everything possible to encourage greater production from the steel plants. That, in turn, means that the steel industry must have more machinery, more labor, more power, more coal, greater transportation facilities and greater plant capacity. The Steel Controller helps to solve these problems. More labor—he will seek the aid of National Selective Service. More electric power—he will consult the Power Controller. More coal—he will enlist the help of the Coal Controller.

The activities of the various controllers, therefore, must dovetail into the broad general scheme, must supplement and be supplemented by the work of others. It would do little good, for instance, if greater steel production were achieved by channelling so much coal, labor, power, and transportation into steel productive

facilities that a handicap would be placed on war plants which would otherwise use the steel produced.

Everything is related. Therefore everything must be co-ordinated. The production programs are established in relation to the needs of Canadian armed forces and the needs of the United Nations. They are established in relation to the needs of other production branches. They are established in line with limitations of plant capacity, material supplies, and power and transportation facilities. Similarly the control programs are established in relation to each other and to the production plans.

In the early stages, restrictions held the spotlight. At that time it was necessary to put the brakes on "business as usual" in order to convert industrial capacity and supplies of raw materials and services from non-essential to essential wartime channels. The fact is frequently overlooked, however, that restrictions would have been much more severe had it not been for positive action to expand the resources of materials and services under control.

Canada's steel production has been doubled since the outbreak of war, to a present annual total of three million tons. Coal production has gone up by more than two million tons since 1939. Installed horsepower is at an all-time high of ten million as against 8.2 million horsepower four years ago. Aluminum output is more than six times that of 1929. Output of sawn lumber reached a peak of 4.9 billion feet in 1941, one billion feet over 1939 production, and is still at annual rate of well over four billion feet in spite of critical labor shortages. All these increases represent positive action as against the restrictive control measures whereby retail coal sales are regulated, dimouts are ordered in certain industrial areas, and some metals are unavailable for many lines of consumer goods, and non-essential construction is closely defined to save lumber and other materials.

There is nothing arbitrary about the rulings of the Control Board. Advisory committees represent every industry or division of industry affected by control

rulings. If and when it is necessary to establish a regulation which works inconvenience or even hardship on any specific branch of Canadian business, those affected have had a chance to be heard, their views have been considered. Restrictive regulations are imposed by absolute necessity for the good of the war production program as a whole. The controls are so completely geared to the administrative and economic setup that they are the servants and not the dictators of the people's will.

Canada has been living in the shadow of extraordinary dangers. To meet those dangers extraordinary measures have been necessary. They have demanded sweeping changes in Canadian life, in the national economy and in the adaptation and expansion of the industrial machine to the arts of war.

Directory of Major Canadian War Products

SHIPS

CARGO VESSELS—10,350-tons (four types)—4,700-tons (one type).

TANKERS—3,600-tons (one type).

COMBAT VESSELS—Destroyers, frigates, algerines, corvettes, two types of wooden minesweepers, Fairmile patrol vessels.

SPECIAL SERVICE SHIPS—Landing ships, tugs (five types), self-propelled personnel landing craft, 72-foot unpowered invasion barges.

SMALL CRAFT—More than 40 types of miscellaneous small boats.

CONVERSION of commercial and pleasure craft for war purposes.

REPAIR of damaged cargo and naval vessels.

COMPONENTS turned out for all types of ships, including engines, boilers, generators, armament, instruments, plates, shapes, etc.

COMPLETED CONTRACTS—76 minesweepers (50 Bangors, 16 Western Isles, 10 diesel). Motor torpedo boats, floating drydock, base supply ships, railway barges, wooden and concrete gate vessels, and scores of other service boats.

AIRCRAFT

TRAINING—Three types.

COMBAT—Four types.

TRANSPORT—One type.

COMPONENTS—Virtually all parts, instruments, armament, propellers, including spares and replacements.

REPAIR—Some 12,000 aircraft in Canada overhauled regularly.

COMPLETED CONTRACTS—Seven types of service planes, eight types of training planes, Link trainers.

VEHICLES

TANKS—M-4 Grizzly cruiser tanks, self-propelled artillery (four types), universal carriers.

ARMORED VEHICLES—Scout cars, armored combat cars, armored personnel carriers.

SERVICE VEHICLES—Wireless trucks (three types), ambulances (three types), field workshops (34 types), fire trucks (three types), trailers (45 types), transport lorries (100 types, 20 different chassis).

MISCELLANEOUS—Locomotives, railway cars, snowmobiles.

COMPONENTS—Motors, chassis, bodies, special equipment for service vehicles, many types of tires.

COMPLETED CONTRACTS—Valentine tanks, Ram tanks, reconnaissance armored cars, several types of service vehicles.

GUNS (ARMY)

BOFORS, 40-mm. anti-aircraft—Standard Army complete equipment (i.e., complete gun on mobile mounting), special Army-Navy equipment, separate guns, spare barrels.

3.7″ ANTI-AIRCRAFT—Complete gun on mobile mounting, separate guns, spare barrels.

25-POUNDER FIELD GUN—Complete gun on mobile mounting, separate guns.

6-POUNDER TANK AND ANTI-TANK GUN—Complete gun on mobile mounting, separate guns on tank mountings, spare barrels.

4.5″-5.5″ FIELD HOWITZER—Interchangeable carriage only.

90-mm. ANTI-AIRCRAFT—Loose barrels only.

COMPLETED CONTRACTS—25-pounder trailers, 2-pounder tank guns on tank mountings, 2-pounder anti-tank guns on mobile mountings, loose barrels only for 4.5″ anti-aircraft guns.

GUNS (NAVY)

2-POUNDER POM-POM—Complete gun, spare barrels, quadruple mountings.

4″ NAVAL GUNS—Three types of complete guns; one type of single, and two types of twin mountings.

COMPLETED CONTRACTS—Single mountings for 2-pounder pom-poms, 12-pounder guns with single mountings, two types of rocket mountings, twin mountings for Vickers naval machine guns.

SMALL ARMS

BREN machine guns—Two types, and tripods.

VICKERS, .5-inch naval machine guns—Complete guns, barrels for Vickers .303-inch machine guns.

20-MM. ANTI-AIRCRAFT GUNS—Complete guns, four types of 20-mm. mountings.

RIFLES—.303-inch No. 4, two types; .22-inch training rifles.

PISTOLS—Automatic pistols for China.

STEN 9-mm. sub-machine carbine—Complete gun.

MORTARS—2-inch trench mortar, 2-inch tank bomb thrower.

COMPLETED CONTRACTS—Browning .303-inch aircraft machine guns, Browning .30-inch tank machine guns, Boys anti-tank rifles, 4-inch smoke dischargers, aiming tubes, 100-round Bren gun magazines, 3-inch trench mortars.

AMMUNITION

FIXED GUN AMMUNITION—40-mm. (two types), 3.7-inch, 4-inch naval, 6-pounder (four types), 2-pounder, and four other types.

CARTRIDGES (FILLED)—25-pounder, 4.5-inch (two types), 5.5-inch (three types), 6-inch, and four other types.

PROJECTILES (FILLED)—25-pounder (three types), 4.5-inch (two types), 5.5-inch (two types), and four other types.

GRENADES—Hand (three types), rifle (two types), and two other types.

MORTAR BOMBS—2-inch (three types), 3-inch, and one other type.

OTHER FILLED PROJECTILES—Depth charges (three types), anti-tank mines (two types), smoke generators (two types), piat bombs, torpedo warheads (two types) and others.

EMPTY CARTRIDGES—40-mm., 3.7-inch, 2-pounder (two types), 6-pounder, 25-pounder, and five other types.

EMPTY SHELLS—Three types.

OTHER COMPONENTS—Primer holders (three types), fuses (13 types), gaines (two types), primers (eight types), tracers, fuse accessories (three types).

MISCELLANEOUS—250-lb. bombs, practice bombs of various types.

COMPLETED CONTRACTS—500-lb. aerial bombs of which several million have been produced, filled, and shipped overseas; and many others.

SMALL ARMS AMMUNITION—.303-inch (five main types); .22-inch, .45-inch, .50-inch, .55-inch, and three other types; 20-mm. Oerlikon and Hispano-Suiza ammunition (six types).

EXPLOSIVES AND CHEMICALS

EXPLOSIVES—Rifle and cannon cordite, rifle and cannon powder, fuse and gun powder, TNT, RDX, and four other types.

CHEMICALS—Hexachlorethane, ammonia, ammonium nitrate, activated carbon, phosphorus, perchlorates, and twelve other types.

MISCELLANEOUS

Armor plate.
Clothing and boots for Navy, Air Force, Women's Auxiliary Corps, Air Cadets, and Naval Cadets Corps.
Refugee and internment clothing.
Personal equipment.
Sighting and optical instruments, (51 types).
Special naval instruments, (65 types).
Binoculars, (two types).
Fire control instruments, (58 types).
Army instrument stores, (50 types).
Radiolocators.
Wireless equipment for the three services.
Gas masks, (two types).
Steel helmets.
Plastic crash helmets.
Parachutes, (two types)
Supply dropping parachutes.
Flare parachutes.
Signal type parachutes.
Towed targets.
Minesweeping gear, (three types).
Technical naval equipment.
Life-saving apparatus.
Searchlights, (10 types).
Smoke generators, (six types).
Marine smoke floats.
Hospital equipment and supplies.
Dental equipment and supplies.
Gas decontamination suits and equipment.
Military furniture and forms.
Military training and sports equipment.
Fire hose.
Asbestos rescue suits and fire smothering blankets.
Steel ammunition boxes, (14 types).
Wooden ammunition boxes and containers.
Machine tools, (four general types in hundreds of sizes).
Gauges of many thousands of types.
Cutting tools.
Anti-submarine equipment.
Torpedo components.

Wartime Industrial Conservation

Wartime shortages of raw materials, of machine tools, and of skilled labor have created problems which could be solved only by conservation.

Manufacturers and their employees, as well as departmental officers, have made great strides in saving critical

materials such as tin, alloy steel, copper, aluminum, nickel, and rubber, and in making the best use of skilled labor and machine tools.

The economies have been effected in various ways: By changes in design, by substitutions of plentiful materials for those in short supply, by changes in production methods, by improvements in handling and packaging operations, by sensible use of time studies, by short cuts in manufacturing processes, and by the conversion of ordinary tools to release specialized tools.

So important have been many of these economies, particularly in the field of substitutions, that Canadian industry in general will benefit greatly in the post-war era.

Here are a few outstanding examples of wartime conservation:

The handle of an inspection lamp supplied with army trucks was once made of rubber. But with rubber a critical material, wood has been substituted and in one plant alone 14 tons of rubber have been saved. The use of canvas for windshield weather strips has enabled one company to save five tons of rubber in the construction of military truck cabs. Another company saves more than 50 tons of sponge rubber each year by substituting hair pads for the rubber back rests and seats of the universal carrier.

Two wheel wrenches were formerly supplied with each army truck. A double-end wrench was designed and substituted, releasing 250,000 pounds of steel for other uses.

Redesign of an ammunition box, which once cost $40 to produce, has resulted in substantial savings in man-hours and materials, and has reduced the cost to $8.91.

A hook for the Bren gun sling, once costing 84 cents, has been redesigned and now a simpler hook is made at a cost of five cents. A combination tool for making adjustments and repairs to the Bren once cost $4.62. It has been replaced by a redesigned, simplified tool, which now costs only 28 cents, saving $800,000 on

current production. A brass oil can for the gun once cost 56 cents. It has been replaced by a plastic oil can at half the price, and by using the plastic, brass is made available for other purposes.

A percussion fuse made in a Canadian war plant was once machined from solid brass bar stock. It was redesigned to be made from a zinc die casting. The change releases more than 43 million pounds of brass and nearly 500,000 pounds of bar steel, saves a million standard hours of labor, releases 18 valuable machine tools for other duties, saves $6 million a year on the cost of production, and enables Canada to turn out fuses cheaper than any other country in the world.

Modification of the design of the Bofors anti-aircraft gun has eliminated 54 parts. The consequent annual saving in material comprises 150,000 pounds of carbon steel, 75,000 pounds of bronze, and 38,000 pounds of stainless steel tubing. Six machine tools and 43,000 hours of labor have been released, and the annual production cost has been reduced by $600,000.

The substitution of wood for aluminum in the manufacture of a map case installed in the Canadian Anson trainer aircraft annually conserves 1,700 pounds of aluminum and more than 7,000 man-hours; this means an annual cost reduction of $9,000. In the production of the aircraft itself conservations effected by Federal Aircraft Limited, by substitutions and redesigns which save raw materials such as rubber and aluminum, amount to $3.5 million a year.

A development, known as centrifugal casting, whereby molten metal is poured into a rapidly rotating mould, is a conservation technique practised by one of the large automotive companies and adopted by other war industries. The centrifugal method produces dense, strong castings which can be substituted for forgings.

The old "green sand" method of casting the front wheel hub of an army truck formerly produced hubs of

an untrimmed weight of 100 pounds. The untrimmed part of the hub is now reduced to 60 pounds, with a consequent saving of metal, furnace hours, furnace capacity, and electrical power demand. Metal wastage, which ran as high as 50 per cent under the old method, has been reduced to as low as five per cent by the new technique. As applied to the production of track sections for the universal carrier, the result is a track which gives double the mileage of its predecessor.

Substitution of webbing for Manila rope in the handles of wooden ammunition boxes effects an annual saving of 1,200 miles of this scarce fibre.

The upper prism holder of a tank periscope, once machined from aluminum casting, is now made of a plastic, releasing 80,000 pounds of aluminum alloy, 800,000 man-hours, and 133 machine tools for a total annual saving of $755,000 on this one item.

An investment of less than $25,000 covered the cost of installing conveyor lines for assembling magazine cases for machine guns and anti-tank rifles. The 17 assembly operations have been so facilitated by the new method that the production increase represents a saving of $1.45 million a year.

The original specifications for the Canadian army rifle, known as "Rifle No. 4, Mk. I," called for a backsight which was an assembly of seven parts, each separately machined. Design men figured out a backsight that would consist of one part instead of seven. The part would be machined from bar stock. Thus all the machining operations previously needed for the seven parts would be eliminated, and substantially less steel would be required.

The change was approved by inspection authorities. The new backsight is as efficient as the original model. On a year's production this one little item represents the release of 37 machine tools for other work, and savings of 319,000 hours of labor and 143,800 pounds of

carbon steel. In terms of cash, this adds up to a saving of $296,000 a year—just by modifying the design of the backsight.

The trigger guard of the rifle was to be machined from a forging. But Canada's metal forging capacity was under heavy pressure to fill war demands. The design was modified to call for a pressed metal trigger guard. This released 64 machine tools, saved 168,000 hours of labor and 868,000 pounds of forgings. The annual money saving is estimated at $208,000.

Other changes were made. The mouthpiece of the bayonet scabbard is now diecast from zinc instead of machined from carbon steel. This releases seven machine tools, saves 90,000 man-hours and 137,000 pounds of steel. The locking bolt, once machined from carbon steel, is now an assembly of two parts. The handle is blanked in a punch press and the stud is made by an auto screw machine. This saves 220,000 man-hours, releases 17 machine tools, cuts the amount of carbon steel needed by 64,000 pounds, represents an annual money saving of $111,500. A design change simplified the machining needed to make the bridge body of the rifle, released seven machine tools. Six tools were released by simplifying the operations in making the cocking piece of the weapon. The catch at the head of the breech bolt was considered unnecessary and was eliminated altogether. This released a dozen machine tools, saved 120,000 hours of labor and 15,200 pounds of carbon steel. A change in the design of the foresight protector saved 65,500 pounds of material and 80,000 hours of labor, and released 13 machine tools. The upper band of the rifle, formerly a hinged assembly of two parts, was redesigned for a saving of 279,600 pounds of carbon steel, 275,000 man-hours and the release of 30 machine tools—an annual cost saving of $144,000.

Altogether, substitutions and redesigns on the No. 4 Army rifle effected an estimated annual saving of more than 2,200,000 pounds of critical metals, more than 1.76 million hours of labor and released 264 machine tools, for a total cost saving of $1.35 million. The design changes were made from time to time before and after

the manufacture of the weapon got under way. The rifle now costs less than half what it cost in the initial stages of its production.

Technicians of the automobile industry, trained in a highly competitive field where small economies amount to big savings in mass production, have contributed extensively toward development of substitute materials and speeding up of production methods. The uses of plywood in the aircraft industry cover a wide range, wood replacing metals in scores of instances ranging from the complete fuselage to small items of interior equipment. All the changes have been approved by inspection authorities and in no case has quality been sacrificed to expediency.

The conservation campaign has been general in Canadian war industry, with prime contractors and sub-contractors throughout the country co-operating in the program. A notable feature has been the contribution made by workers in the plants, through the "suggestion box" scheme adopted in many war factories, whereby workers receive awards of War Savings Certificates or Victory Bonds for time-saving, labor-saving, or material-saving ideas. The majority of the hundreds of award-winning ideas have been improvements in shop methods.

The Canadian program has been closely linked with the United States conservation programs through the Conservation Sub-Committee of the U.S. and Canada Joint War Production Board. The Munitions and Supply Department has maintained a conservation liaison representative in Washington who has passed on new ideas to the Americans and obtained for Canada the new ideas developed in the United States. While the U.S. conservation programs have been administered by staffs numbering several thousand, the successful Canadian program has been developed with a minimum of administrative staff. All production branches of the Munitions and Supply Department simply adopted conservation as an essential feature of their respective programs. Representatives of the production branches, controls, inspection boards and service staffs met regularly in sessions of the Conservation Committee.

An exhibit of more than 1,000 items of conservation in Canadian war industry was held in Toronto, Montreal, and Ottawa, during 1943, demonstrating savings totalling millions of dollars and thousands of tons of critical materials in current Canadian war production; later it was sent to Washington, D.C. The exhibit showed some of the astonishing results that have been achieved by Canadian ingenuity and by the pooling of information which has been going on since the Munitions and Supply Department launched its industrial conservation campaign in October, 1942.

AIRCRAFT

"A LITTLE to starboard, Harold . . . Steady . . . There, hold that!" Bomb aimer F/O John Astbury, of Portage la Prairie, Manitoba, lightly touched a button. "Bombs away!" he reported over the plane's intercom system, and the "Ruhr Express," lighter by eight tons, lifted sharply and turned for home through a thick curtain of flak. The first Canadian-built Lancaster bomber was over enemy territory for the first time since her maiden flight from the factory at Malton, Ontario.

From the "Silver Dart," the first heavier than air machine to fly over British soil, at Baddeck, N.S., to the "Ruhr Express," the world's heaviest bomber, Canada had come a long way in the production of flying machines.

The expansion of the aircraft industry has been dramatic. From a modest undertaking employing 1,000 workers, it has developed since the beginning of the war into one of Canada's most important industries, employing more than 120,000 men and women. The average annual output of the industry during the five years which preceded the war was about 40 planes; in 1943 it exceeded 4,000. Plant floor space has increased from a mere 500,000 square feet to more than 14 million.

Progress in the field of wartime aircraft production in Canada is indicated by the following figures:

Dollar Value of Output (Including Overhaul)

1939-40	$ 42 million	1942	$216 million	1943	$325 million
1941	$100 million			Total	$683 million

Number of Aircraft Produced (All Types)

1939-40..904	1941..1,699	1942..3,781	1943..4,133	Total..10,517

The 10,517 planes produced in Canada are divided as follows: advanced trainers, 4,183; elementary trainers, 3,302; and service aircraft, 3,032.

In the foregoing tabulation, the disparity between the large increase in dollar value and the relatively small increase in volume for 1943 is the direct result of a changeover from small, medium training, and service planes to costlier, heavier, and more complex combat aircraft such as the Lancaster, the Mosquito, the Catalina, and the Hell Diver. The difference between a Lancaster and an elementary trainer is proportionately as great as that between a battleship and an escort vessel. The four-engined bomber is 22 times heavier than the Cornell, has 30 times its horsepower, and costs about 35 times more. The tail-span of the Lancaster is greater than the total length of the Cornell.

History

There were two outstanding early contributions to aeronautical development in Canada. One was the work of the Aerial Experiment Association headed by Doctor Alexander Graham Bell at Baddeck, Cape Breton, commencing in 1907. This association designed and flew several of the earliest heavier-than-air machines in

the British Empire. The other major contribution was the basic research work in the science of aerodynamics prior and subsequent to 1907 by Wallace Rupert Turnbull, of Rothesay, New Brunswick. Turnbull's chief claim to fame lies in the invention of the electrically controlled, variable pitch, constant speed propeller.

There were no notable accomplishments in this field in the Dominion from 1909 to 1916 when J. A. D. McCurdy established the first aircraft factory in Canada, Curtiss Airplanes & Motors Limited. During the last war, this firm and its successor, Canadian Aeroplanes Limited, established a truly remarkable record by producing 3,000 planes constructed mainly of wood and fabric.

Following the armistice, aeroplane manufacture in Canada was discontinued, and it was not until 1923, when Canadian Vickers Limited was given an order by the Canadian Air Board for eight single-engined amphibians, that a revival took place. Prior to this war, however, aircraft production was not a major industry in Canada.

When the Stukas and the Messerschmitts began to paralyze the countries of Europe, it was felt that British production alone could not supply all the planes needed to oppose the Axis, and Canada was called upon to contribute to the air power of the Empire, if only by meeting the major requirements of the Commonwealth Air Training Plan. At the outbreak of the war, Canadian plants had contracts for about 200 warplanes —Lysanders, Bolingbrokes, Sharks, and Stranraers for the Department of National Defence, and Hampdens and Hurricanes for the British Government. No planes had been delivered. Assembly lines were largely in the blueprint stages.

In January, 1940, 100 Harvards were ordered; in February, 808 Tiger Moths and Fleet Finches. Other contracts let during the first half of 1940 were for the large-scale production of wings and ailerons for British-made Ansons, and the assembly of Fairey Battles.

Then France fell. Shipping to and from the United Kingdom became a serious problem. The Commonwealth Air Training Plan was in jeopardy. So Canada undertook to build complete Ansons. Arrangements were made to buy engines from the United States. Federal Aircraft Limited, a Crown company, was created to co-ordinate the program under which several thousand Ansons of three different types were ultimately built.

Yet, as late as September, 1940, Canada still had wholly inadequate aerial protection. An emergency conference was held, out of which grew plans to build combat types in Canada. But the road was not an easy one. The program on the Catalina coastal reconnaissance bomber was started. Substantial additional orders for Bolingbrokes and Hurricanes were placed. United States fighters and bombers were considered, but were ultimately abandoned in favor of the Mosquito and the Lancaster. By July, 1941, Canadian plants had over 5,900 planes on order.

In 1941, it became apparent that more training planes must be built to meet the needs of the Commonwealth Air Training Plan. Intelligent long-range production was arranged, and the expansion of manufacturing facilities planned accordingly.

Despite the many delays which the industry experienced during the changeover and retooling periods, Canada, by the end of 1942, had emerged with a well-rounded program consisting of nine top-ranking planes, only one of which has been dropped since the new program was established.

Since the outbreak of the war, Canada has brought to a successful conclusion the following aircraft contracts: Elementary trainers: 1,384 Tiger Moths, 10 Menasco Moths, 126 Wireless Moths, and 431 Fleet Finches. Advanced trainers: 101 Fleet Forts, and 225 Lysanders (33 per cent of which were of the army co-operation type). Service aircraft: 15 Sharks, 15 Grummans, 32 Stranraers, 8 Deltas, 160 Hampdens, 626 Bolingbrokes, and 1,451 Hurricanes. Under contracts still in effect,

the following planes had been produced at December 31, 1943: 280 Norsemen, 1,650 Harvards, 2,250 Ansons, and 1,351 Cornells.

In addition to the actual manufacture of planes, Canada has assembled 3,200 aircraft from Great Britain, and purchased more than 3,000 in the United States. A total of 2,500 service aircraft built in the Dominion have been delivered to the United Nations in various theatres of war.

It is largely through the initiative of the Department's Aircraft Production Branch that Canada today has a balanced aircraft program comprising the most modern types, and orders on hand for 1944 and a part of 1945. It conducted widespread surveys to ascertain how far the Dominion could go in the production of large aircraft of the latest design, created the facilities needed for their manufacture, and sold Britain and the United States on the idea that Canada could mass-produce virtually any type of aircraft in the air today. With orders on hand for more than $750 million, involving the construction of some 10,000 additional planes, the aircraft industry of Canada may well point with pride to its record of achievement.

Directory of Canadian Aircraft Types and Plants

THE LANCASTER—Four-engined bomber. Wingspan, 102 feet. Length, 69 feet. Height, 20 feet. Gross loaded weight, 30 tons. Engines, 4 Packard Merlins. Maximum speed, about 300 miles per hour. Maximum range, 3,000 miles. Length of bomb compartment, 33 feet. Maximum bomb load, eight tons. Armament, ten Browning .303″ machine guns in four revolving turrets: nose, tail, mid-top, mid-belly.

The Lancaster, one of the world's heaviest bombers, has tremendous speed, an enormous bomb load, highly effective defensive armament and extreme manoeuvrability. Its record of achievement as a weapon of destruction has not been equalled by any other aircraft. Lancasters have been largely responsible for the destruction of large sections of Berlin.

Designed by Roy Chadwick, of the British firm of A. V. Roe, it is being built in Canada by a Crown company, Victory Aircraft Limited, created to operate the Malton aircraft plant of the National Steel Car Corporation Limited. The plant was acquired in November, 1942, to effect better co-ordination between the plant management, the Department, and the British designers and builders, and to eliminate certain difficulties which threatened to impede production of the giant plane.

Largest aircraft factory in the Dominion, Victory Aircraft Limited has a plant floor space of more than a million square feet, and the total estimated value of buildings, machinery, and equipment is about $6.5 million. The plant, which aims to employ more than 10,000 when it reaches maximum output, now has about 80 per cent of this number at work.

Prior to the Lancaster contract, Victory Aircraft, then National Steel Car Corporation, had turned out 225 Lysanders (of which 33 per cent were of the Army co-operation type), 736 Canadian Ansons, and 100 Anson fuselages. It had assembled 112 Yales, 26 Harvards, and 17 British Ansons, and produced 200 Hurricane wings, and 80 Hampden wings.

THE MOSQUITO—Twin-engined fighter or bomber. Wingspan, 54 feet. Length, 41 feet. Height, 15 feet. Engines, two Rolls-Royce Merlin. Maximum speed, said to be around 400 miles per hour. Maximum bomb load for the bomber type, 3,000 pounds. Range, more than 1,600 miles. Armament for the fighter type, four 20-mm. cannons, and four .303″ machine guns.

The Mosquito is a wonder plane, the most versatile firstline aircraft in the world, the fastest, and the most manoeuvrable. It is in service in several versions: day and night bomber, long-range day and night fighter, intruder, and others. Created in England by a team headed by Captain Geoffrey de Havilland, it is manufactured in Canada by de Havilland Aircraft of Canada Limited, a subsidiary of the British firm. The Canadian de Havilland plant, located at Toronto, Ontario,

employs more than 5,000 men and women, has a plant floor space of 650,000 square feet, and operates one of the largest private airfields in Canada.

Before switching over to the production of Mosquitos, de Havilland of Canada had produced 1,384 Tiger Moth elementary trainers, and several hundred Canadian Ansons.

Main feature of the Mosquito is its all-wood construction which was adopted largely to tap new material supplies, and to employ less critical manpower. In addition, it has several other advantages such as buoyancy, ease of repair, and greater resistance to firepower.

THE CATALINA—Twin-engined ocean patrol and coastal reconnaissance bomber. Wingspan, 104 feet. Length, 64 feet. Height, 20 feet. Gross loaded weight, 14 or 17 tons. Powered by two twin Wasp engines. Maximum speed, 200 miles per hour. Range, more than 3,000 miles. Armament, four machine guns: two in nose, one in each of two blisters straddling rear fuselage. Plane is equipped for bomb, depth charge, or aerial torpedo installation. Maximum bomb load, 4,000 pounds.

The Consolidated PBY5, better known as the Catalina (Canso for the R.C.A.F.), is one of the most famous planes in the world. It has the greatest range of any twin-engined aircraft. It is recognized as the world's best naval patrol bomber, and while it is an old plane in terms of modern design, no aircraft of its type has yet been created during the war which can outperform the Catalina as a convoy protector and submarine detector. It has an unparalleled record of service, having withstood terrific punishment, and performed almost miraculous feats before and since the beginning of the war. It was a Catalina that located the Bismark and made her sinking possible.

In Canada, two versions of this famed American plane are in production. Boeing Aircraft of Canada, Vancouver, is turning out the flying boat type, and Canadian Vickers Limited, Montreal, is producing the amphibian type. The former lands and takes off from the sea, while the

latter is equipped with special undercarriage permitting landing and take-off on both water and solid ground.

No aircraft contract in Canada employs a greater number of workers than the Catalina. More than 19,000 men and women are on the payrolls of the two firms which build it. Factory floor space in the four Boeing plants is around one million square feet, while Vickers has about 750,000 square feet. Past wartime production at Boeing's includes Blackburn Sharks, British torpedo aircraft and Anson components, while Vickers' includes the supermarine Stranraer, a British flying boat, and the main fuselage sections for the Hampden bomber.

THE HELL - DIVER—Single-engined naval scout and dive bomber. Powered by a Wright twin Cyclone engine. Maximum speed more than 300 miles per hour. Bomb load, over 1,800 pounds. Crew of two. Heavily armed. The Curtiss Hell-Diver is another outstanding American aircraft. It is recognized as the latest and most powerful dive bomber in the world.

Late in December, 1943, it was disclosed that the Hell-Diver had been in action at Rabaul on November 11 and had inflicted heavy damage on Japanese warships, sinking a light cruiser and a destroyer. It was revealed by the United States Navy's Bureau of Aeronautics that the plane is the biggest and heaviest dive bomber ever used by any of the American forces, that it flies as fast as a fighter, carries two bombs instead of one, and can land on the smallest aircraft carrier because of its special flaps and wing tips. It was further disclosed that one-fourth of the entire Hell-Diver production is being handled in Canada.

Two large Canadian contractors are turning out the Hell-Diver. The firms are Canadian Car and Foundry Co. Ltd., which is building Hell-Divers in its Fort William plant, and Fairchild Aircraft Limited, Longueuil, Quebec. Canadian Car operates four aircraft plants, and a propeller factory. It has more than 12,000 workers on its aircraft payrolls, more than 5,500 of whom are in the Fort William shops which occupy almost one-half of the company's one million square feet of aircraft factory floor space.

Before going into production of the Hell-Diver, this plant delivered 1,451 Hawker Hurricane fighters, the first one of which was delivered in January, 1940, and the last one in May, 1943. The Hawker Hurricane is a single-engined pursuit aircraft. Wingspan, 40 feet. Length, 31 feet. Height, 13 feet. Powered by one Rolls-Royce Merlin 28. Maximum speed, 335 miles per hour. Range, 830 miles. Armament, eight machine guns, or four 20-mm. cannons in wings.

Although it is no longer in production in Canada, the Hurricane has been the main production item on the Dominion's service aircraft program. Canadian-built Hurricanes have seen action in virtually every theatre of war. They have been catapulted from ships to fight enemy aircraft and submarines. Flown by Canadian and other United Nations pilots, Fort William Hurricanes have played a big part in the day and night offensive against the enemy in occupied Europe. One squadron, part of the wing of night fighters which opened the air attack during the Dieppe raid, knocked out 11 enemy planes. Other Canadian Hurricanes have been in operation with the Chinese R.A.F. fighter squadron whose chief targets have been locomotives hauling war supplies in occupied France.

The other Hell-Diver contractor, Fairchild Aircraft Limited, has nearly 7,000 employees, and a factory floor space of 883,800 square feet. Its main production item, before engaging in Hell-Diver manufacture, was the Bristol Bolingbroke, contracts for which were completed in the summer of 1943 when the 626th Bolingbroke was delivered.

The Bolingbroke is a medium-range, twin-engined plane, originally produced as a bomber and reconnaissance aircraft, but more recently turned out as a bombing and gunnery trainer. Wingspan, 56 feet. Length, 43 feet. Height, 10 feet. Gross loaded weight, 7½ tons. Powered by two Bristol Mercury XV engines. Maximum speed, 262. Range, 1,500 miles. Maximum bomb load, half a ton.

Designed before the war, the Bolingbroke, often called "the long-nosed Blenheim," has been in action the

world over. The R.C.A.F. uses a number of them on patrol duty, especially in Alaska where they are still rendering yeomen service.

THE NORSEMAN—Single-engined transport, flying school, and general utility craft. Wingspan, 52 feet. Length, 32 feet. Height, 10 feet. Gross loaded weight, 3¾ tons. Powered by single P.& W. Wasp R1340AN. Maximum speed, 170 miles per hour. Range, more than 1,000 miles. Quickly convertible from wheels to floats or skis. Carrying capacity, six to eight passengers, in addition to the crew of two; or a cargo payload of one ton.

The Norseman, well known throughout the north country, is of Canadian design, and the only Canadian plane to be used extensively during this war, both as a trainer and as a service aircraft. It was recently listed as the best medium-range transport plane in the world. Its sterling qualities have been recognized by the United States Army Air Forces. Designer and manufacturer of the Norseman is Noorduyn Aviation Limited, one of Canada's largest aircraft companies, which employs 10,000 workers, and occupies 688,000 square feet of factory floor space. This firm also produces the Harvard.

THE HARVARD—Single-engined advanced trainer. Wingspan, 42 feet. Length, 29 feet. Height, nine feet. Gross loaded weight, 2½ tons. Powered by a single P.& W. Wasp R1340AN. Maximum speed, 205 miles per hour. Range, 725 miles.

From a quantity standpoint, the Harvard is, after the Anson, the largest single production item on Canada's entire aircraft production program. The Harvard, or AT-16, is built by Noorduyn under licence from North American Aviation Inc. It is the most widely used aircraft in the Commonwealth Air Training Plan, and the most familiar to Canadians, who have seen thousands of these bright-yellow craft swarming around airfields throughout the Dominion. It is of all-metal construction, and equipped with complete dual instrument installation and controls, as well as one machine gun, one camera gun, and a small bomb rack for bombing practice.

THE CANADIAN ANSON—Twin-engined advanced navigational trainer. Wingspan, 56 feet. Length, 42 feet. Height, 13 feet. Gross loaded weight, 4½ tons. Powered by two P.& W. Single Wasp Jr. engines. Maximum speed, close to 200 miles per hour. Flight duration, five hours.

Successor to the British Avro-Ansons, the Anson V is a Canadian product in design and manufacture. It is intended for training navigators, wireless operators, and bomb aimers, and embodies several refinements of equipment based on the experience of the Commonwealth Air Training Plan. Like the Mosquito, the Anson V is an all-wood plane, using Canadian red pine in its moulded plywood fuselage.

The Anson has been the most important Canadian contribution to the Commonwealth Air Training Plan. Original orders for 1,832 Ansons Mk II have been completed, and more than 400 Ansons Mk V have been delivered under new contracts. While the Anson V program has been cut by 50 per cent, sufficient orders are on hand to keep plants engaged in the manufacture of this plane working until 1945.

Another version of this aircraft, the Anson VI, similar to the Anson V but with an added revolving machine gun turret, is planned for production during 1944. It will be a bombing and gunnery trainer, performing the same functions as the Bolingbroke trainer. A prototype of the Anson VI was test-flown in September and proved highly satisfactory.

The Anson program is administered by Federal Aircraft Limited, a Crown company established in June, 1940, to co-ordinate and expedite the production of this essential trainer.

Under the Commonwealth Air Training Plan, it was originally intended that Great Britain would provide all the components for the Anson, except the bare wings, which were to be manufactured in Canada. In the spring of 1940, however, it was decided to manufacture the

complete plane in Canada because of lengthy delays in the delivery of parts from the United Kingdom.

Since the beginning of the Anson program, Federal has acted as the principal purchasing agent for raw materials and necessary parts and components. Its scope in this connection has expanded to include virtually all the finished parts, sub-components, and standard parts, and the large number of spares required for maintenance. The spares program is well in hand, and deliveries are keeping pace with the production program. Federal also purchases most of the instruments formerly provided by the R.C.A.F. As a result of its increased purchasing activities, the stores requirements of Federal Aircraft Limited grew to such proportion that it became necessary during 1943 to establish a new Anson central store in Montreal eliminating the four smaller stores previously operated in different parts of the city. The new arrangement reduces stores and transportation costs, and speeds up service.

Federal Aircraft Limited also operates its own plant in Montreal. While this factory is to be closed in the near future, it has played an important role in the Anson program and is worthy of mention. It occupies a floor space of some 70,000 square feet, and employs close to 1,000 men and women. This figure, however, includes the Federal Aircraft general administrative staff. Work at the Federal plant consists mainly of fuselage assembly.

The original Anson program utilized the final assembly service of five aircraft companies. Two contractors, one in Winnipeg, the other in Amherst, N.S., now provide the full complement of completed Ansons.

The moulded plywood process used in building the Anson is known as the Vidal process. The earlier Anson II airframe was made of welded steel tubing and wood covered with fabric, but to conserve critical materials, the fuselage was changed over from metal and fabric to wood. Under the Vidal process thin veneers of red pine, poplar or similar woods precoated with urea-formaldehyde glue are laid in successive layers

at 45 or 90-degree angles over a form. These sheet structures on forms are enveloped in a rubber bag which keeps moisture from the plywood, placed in an autoclave, and then processed at a temperature of 240 degrees at a pressure of 70 pounds or greater. To provide a Canadian source for the moulded veneer fuselages, arrangements were made for the erection of a new plant at Brantford, Ont., not only for the manufacture of the fuselage, but for the production of numerous sub-components by the same method. The plant went into operation in the spring of 1943 and is now producing at required capacity.

THE CORNELL — Single - engined elementary trainer. Wingspan, 36 feet. Length, 28 feet. Height, 8 feet. Gross loaded weight, 1¼ tons. Powered by one Ranger 6-44005 engine. Maximum speed, 135 miles per hour. Range, 500 miles.

The Cornell is a first-class primary-intermediate trainer. Like all other Canadian-made aircraft, it is the best in its field. A Canadian version of the U.S. Fairchild PT-26 (Freshman), it is the only type of elementary training plane now being built in Canada. It is manufactured at Fort Erie, Ontario, by Fleet Aircraft Limited, which employs approximately 3,000 men and women in its production. The Fleet plant has a floor space of more than 250,000 square feet. Before it built Cornells, this plant turned out 101 of its own Fleet 60 (Fort) advanced trainers, and more than 430 Fleet 16 (Finch) elementary trainers. Its output of Cornells, at the end of December, 1943, exceeded 1,300.

Components

Producing an aircraft is comparable to assembling a gigantic jigsaw puzzle the parts for which would come in different sizes from every corner of the country. In addition to the eight primary contractors engaged in aircraft production in Canada, there are nearly 300 sub-contractors and miscellaneous manufacturers turning out the thousands of components required in the building of planes—wires and pipes, instruments and propellers, and wings and fuselages. Hundreds of tons of aluminum

sheet and parts are supplied to primary and intermediate contractors, from the Toronto and Kingston plants of the Aluminum Company of Canada. In turn, these factories receive their rough aluminum ingots from the Arvida plant, where thousands more are employed.

Building an airplane involves such other factors as engineering and planning, factory buildings and labor, machine tools and equipment. Often, when a plane is about ready to fly, design changes will be ordered which necessitate re-engineering, new tools, and prolonged delays. Both the Lancaster and the Mosquito had to be re-engineered for material and equipment which were available on this continent. In the instance of one service aircraft being built in Canada, modification and engineering orders totalled no fewer than 60,000.

It stands to the credit of the Canadian aircraft industry that all these problems have been met and overcome. Contractors have often had to effect their own re-engineering, and have had to tool up, and produce from sample parts and components.

The procurement problems of the aircraft industry are innumerable. Communications material, wheels, armament, bolts, and nuts have all to be brought together at the same place, at the right time. To avoid many of the delays and disappointments of relying on outside sources, facilities have been created to produce in Canada all aircraft components, except engines, and a few instruments which can be imported more easily than they can be made here.

Canada today turns out such complex aircraft parts as the hydraulic system, an item which would have been impossible four years ago. All the undercarriages are made in the Dominion and some, for the Hurricane and the Lancaster, for instance, are exported to England. Two types of controllable metal propellers, and various types of wooden airscrews are also in volume production, as well as intricate navigation equipment including such items as bombsights, bomb racks, drift sights, recorders, compasses, computers, astrographs, and astro-compasses. At the beginning of the war, no aircraft instruments

were being made in Canada. Today, a complete range, including the intricate sensitive altimeter, are being turned out in large quantities. An eastern Ontario factory has delivered hundreds of Link trainers, the famed flying machine which never leaves the ground. Training schools have been amply equipped with the Link, and production is now being stopped.

Overhaul

An aircraft is not built to last forever. In take-off and landing operations it is subjected to terrific punishment which is often sufficient to damage it. In flight, it suffers a great deal of wear and tear. Planes, therefore, must be overhauled regularly by trained experts, a task which is almost equivalent to building a new aircraft, since the machine brought in for reconditioning must be literally torn to pieces and reconstructed from nose to tail.

To keep its more than 12,000 service and training planes in the air, Canada has created an aircraft repair and overhaul program which is second to none. It is carried out in twenty major plants, assisted by 65 smaller contractors, and 50 ancillary firms. The main contractors are strategically located from coast to coast, and can handle any type of plane from a hedge-hopper to a four-engined bomber. The Canadian aircraft overhaul industry employs 18,000 men and women, and occupies two million square feet of factory floor space.

Since the beginning of the war, this civil repair organization has delivered to the services more than 8,000 aircraft and 20,500 aircraft engines. There are no fewer than 25,000 engines to be serviced in Canada. The Overhaul and Repair Division of the Aircraft Production Branch is delivering back into service each month an average of approximately 200 planes and approximately 1,000 engines. Involved in this work is a chain of plants from coast to coast with a total personnel employed of 17,863.

The amount of capital assistance to plants in this industry exceeds $15 million, and the rate of annual

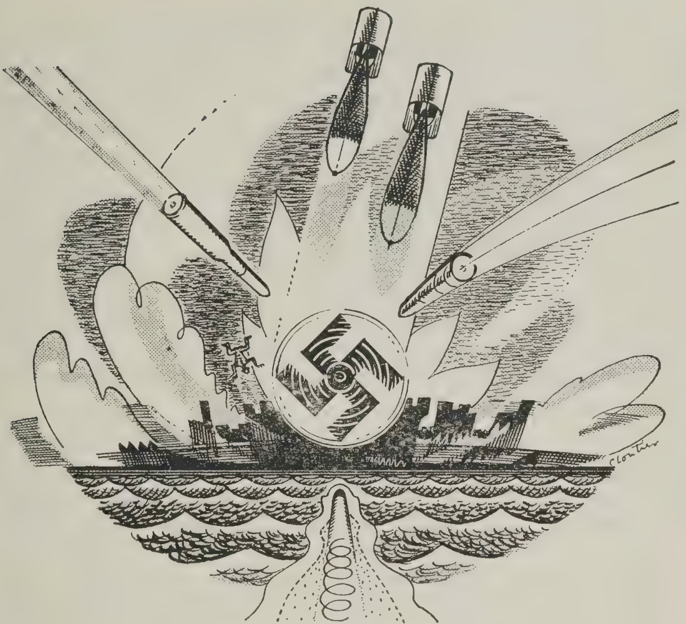
expenditure, exclusive of the cost of parts and materials, is double the pre-war net value of products of the Canadian automotive industry.

Aircraft Control

In order to prevent the unauthorized use of government-owned facilities in the repair of civilian aircraft, and to eliminate production delays resulting from unwarranted design and construction modifications in aircraft components, the Director General of the Aircraft Production Branch was appointed Aircraft Controller in June, 1942.

In September, 1942, an order was issued restricting the manufacture and assembly of aircraft to the completion of contracts placed by the Dominion Government, or approved by the Controller. The order also provided that no person might introduce any modification, change, or addition into aircraft produced for the Crown except on instructions from the controller. It was further decreed that no repair or overhaul contractor, under contract with the Crown, might employ government-owned facilities to repair and overhaul aircraft not covered by such contract, except by permit issued by the Aircraft Controller.

The continued expansion of Canada's aircraft industry results in increasingly complex problems, many of which stem from the necessity of obtaining parts from hundreds of sub-contractors scattered across the country.



AMMUNITION

THE staccato rat-tat-tat of machine guns, and the hollow boom of heavy guns, have become familiar sounds on Canadian proving grounds.

These weapons are constantly testing Dominion-made ammunition, as it flows, a gleaming river of copper, brass, and steel, from wilderness factories to the fighting men on all fronts.

Canadian ingenuity has worked this near-miracle, Canadian ingenuity plus the war itself. For despite its inherently destructive nature, modern mechanized warfare has acted as a powerful stimulant on industrial progress, particularly in the development of mass production methods. And nowhere, perhaps, is this fact more strikingly illustrated than in Canada's output of shells, bombs, and small arms ammunition.

The record is the more remarkable since much of the work being turned out is the product of this war. During 1914-1918, shells were made in large quantities in Canada, but it was not until late in that conflict that the more difficult components and assemblies, such as fuses, were produced in substantial quantities.

In this war, however, Canada not only has produced many millions of shells and billions of rounds of small arms ammunition, but has created a new industry whereby shells are filled with various explosives and shipped overseas as complete rounds of ammunition. Moreover, Canadians have been called upon to turn out enormous quantities of depth charges, anti-tank mines, aerial bombs, trench mortar bombs, and pyrotechnics for the armed forces.

The ammunition industry did not really begin its tremendous expansion, however, until France fell and the British Empire found itself standing alone to face a ruthless, well-armed enemy. Britain, its factories subject to continuous bombing and expecting invasion, was forced to look searchingly across the Atlantic for vitally-needed supplies. Since then, the Canadian war-time output of ammunition has doubled, trebled, quadrupled.

Small peacetime arsenals have mushroomed over an area equivalent to that occupied by a fairly large city. Foundries and machine shops have spread themselves similarly to meet the common need. Hundreds of plants manufacturing non-essential goods have been converted, rapidly and efficiently, to war production. Thousands of workers have been recruited and are now working on vital production. A force of women and girls has been trained to unfamiliar tasks. Mountains of raw materials, many of them coming from new or moribund native sources, have been amassed. A greatly augmented supply of machine tools has been accumulated.

These elements of production have been merged under hastily-erected roofs, many of them hidden away from prying eyes. Like the tributaries of a great river, their union has swelled into a steady stream flowing to the fighting men of the Allies.

No Canadian production story is more complex than that of ammunition. It involves the manufacture of everything hurled at the enemy by hand, rifle, mortar, and gun; dropped on his head from the air; thrown at his submarines from the deck of a ship; or left under a few inches of dirt to smash the tracks of his tanks. It also involves a constant output of the many components which make up these projectiles—the mobilization, expansion, and co-ordination of the ancillary industries which turn out the thousands of tons of steel, brass, and other metals with which the projectiles are fashioned, the paints and lacquers to finish them, the containers to pack them in, and the explosives of various types which give the projectiles their devastating punch.

Ammunition does not merely consist of a hollow piece of steel loaded with an explosive. Many parts call for exacting workmanship and precision. Shells have to be machined to the closest of tolerances, and fuses are often as intricate as watches. It is not a job for unskilled hands.

A complete round of gun ammunition comprises three parts:

1. The cartridge case which contains the propelling charge, usually cordite. It is equipped with a primer which detonates it. In most instances, it is larger than the shell. It can be reformed, refilled, and used a number of times. The majority of cartridge cases are made of brass drawn in one piece to form a cylinder having a heavy flat base with a thin wall tapered to fit the end of the shell. In this is placed the propellent, which when detonated sends the shell to its destination.

2. The shell which is filled with the bursting charge: Amatol, T.N.T., or other types of high explosive. It is fired from the gun by the propellent in the cartridge. Shells are made of steel, with a copper driving band near the base which rotates the projectile in the rifling grooves of the gun and gives it greater range and accuracy. In addition to explosive shell, there is solid shot. Such shot is high-grade steel specially heat treated to be used against tank and other armor plate.

3. The fuse which may contain fulminate of mercury or a like explosive. Its purpose is to detonate the shell, either when it strikes (percussion fuse), or at a given time after it has left the gun (time fuse).

So that her sailors, soldiers, and airmen, and those of the other United Nations, may attack the enemy under every possible circumstance of war, Canada has made a great diversity of ammunition. This output comes within three classes:

1. Gun ammunition, comprising a wide variety of calibres and types.

2. Bombs, including aerial bombs, mortar bombs, grenades, mines, and depth charges.

3. Small arms ammunition.

The first two classes are grouped under the designation of "heavy ammunition," as opposed to the third class which includes only the projectiles for rifles, machine guns, carbines, revolvers and other small arms.

Heavy Ammunition

In the hills of Italy a battery of heavy guns speaks and an enemy ammunition dump goes up in a burst of smoke and flame. Those heavy shells were probably manufactured in a Canadian plant where skilled artisans take the huge, rough shell forgings and, with the help of the most modern methods and machinery, fashion them into the gleaming, finished product.

By the end of 1943, 59 million complete rounds of filled ammunition had been delivered. This figure covers gun ammunition, bombs, depth charges, grenades, and other projectiles other than small arms ammunition. In addition, deliveries also included separate filled shells and cartridge cases numbering some 7 million units. During the last quarter of the year, deliveries of complete filled rounds of projectiles other than small arms ammunition were running at the rate of 2.75 million per month.

Production of shells, armor-piercing shot, practice and proof shell and shot, amounted to 55 million up to the end of 1943. Deliveries from manufacturing plants

during the last quarter of 1943 were at an average of 1.4 million per month. Shells are manufactured in 16 calibres of 21 different types, and include 40-mm., 3.7-inch, 6-pounder, 4-inch naval, 25-pounder, and several types of howitzer shells. Several types have gone out of production.

The average monthly production of cartridge cases during the last three months of 1943 was 3.6 million. At December 31 of that year, 97 million cartridge cases had been turned out. Canada has produced 16 types of cartridge cases, including 40-mm., 3.7-inch, 6-pounder, 4-inch naval and 12-pounder naval.

More than 27 million bombs have been produced, including aerial and mortar bombs, anti-tank mines, grenades, depth charges and smoke generators. Bomb production for the past three months has been at an average of more than 1.8 million per month. All told, 17 types, requiring 50 different types of components, are produced under this bomb program. Contracts for many types of bombs have been completed, among them an order for 500-pound aerial bombs, more than 200,000 of which had been delivered when production was terminated. Smoke, illuminating, and signal bombs also are being produced, as well as hundreds of thousands of practice bombs.

More than 50 types of fuses, primers, and other such components are made in Canada. No fewer than 140 million fuses, gaines, primers, tracers, and tubes, all important components, were produced up to the end of 1943. The average monthly production during the last quarter of the year was almost four million units per month. In one type of percussion fuse, there are 25 parts, each involving a number of distinct operations, and each operation, in turn, requiring precision and close scrutiny.

To package these many types of ammunition, more than 12 million steel boxes have been produced, as well as 2.5 million wooden boxes, 30 million service cylinders and containers, and seven million small arms boxes and liners.

One of the most important items on the bomb production program today is the projectile for the P.I.A.T. (Projector Infantry Anti-Tank). This rocket-like projectile is shot from a weapon which has replaced the Boys .5-inch anti-tank rifle, now considered obsolete. Several thousand rounds of the piat projectiles are scheduled to be produced in 1944. More than twenty firms are turning out parts for this bomb.

Small Arms Ammunition

A lone German aircraft hovers over the English Channel. Abruptly, a pencil of light pierces the darkness. Tracer bullets find the mark and the lurking Hun crumples into the sea, a flaming, smoking victim of a deadly combination of ball, incendiary, and armor-piercing ammunition from the machine guns of an R.C.A.F. plane.

Those projectiles were perhaps fashioned by the deft hands of French-Canadian girl workers in the vast Dominion Arsenal at Quebec City, or in one of the half-dozen big bullet factories built by the Crown and operated on its behalf by private enterprise.

The 25,000 employees of the Canadian wartime small arms ammunition industry, more than half of whom are women, have delivered 3.3 billion rounds of small arms ammunition since the outbreak of war, enough bullets to destroy the entire population of the world one and a half times, or to make an ammunition belt which would encircle the globe.

In 1943 alone, 1.5 billion rounds were delivered, 25 per cent more than in 1942. This means 125 million rounds per month—more than four million per day—500 bullets streaming off to the fighting fronts every single second of the year.

Small calibre projectiles made in Canada range from the .22-inch to the one-inch, and comprise 18 different types including the .303-inch, .380-inch, 9-mm., .455-inch, .5-inch, and .55-inch armor-piercing. The largest production item is the .303-inch used in rifles, Bren guns, and machine guns. This bullet is turned out in four types: ball, tracer, armor-piercing, and incendiary. A very

important single type production item, however, has been 9-mm. ammunition used in the Sten sub-machine guns. It is the standard ammunition for many nations, including Russia.

Small arms ammunition is almost as complex as heavy ammunition. Even with modern equipment and production methods far superior to those used in the last war, the manufacture of a complete round requires approximately 100 different operations.

Production of some types of small arms ammunition was sharply curtailed towards the end of 1943, but there has been a heavy increase in orders for 20-mm. (.80-inch) anti-aircraft ammunition. Several types are made in Canada for both the Oerlikon anti-aircraft gun, and the Hispano-Suiza aircraft cannon. While the 20-mm. is classified as small arms ammunition in the British Empire, it is not so classified in the United States. This projectile is produced in Canada under the management of the Arsenals and Small Arms Ammunition Branch, and manufactured in some of the plants hitherto engaged in the production of rifle and machine gun ammunition.

Historical

Heavy Ammunition—At the outbreak of the present war, there were few facilities in Canada for the production of heavy ammunition. There were, however, two plants, erected in 1937 and 1938, and two other plants manufacturing explosives. The many plants used for shell and cartridge case manufacture during the first world war had been dismantled and scrapped years ago.

Small as the existing facilities were, they formed the foundation on which Canada was able to build a vast industry capable of turning out hundreds of thousands of rounds of heavy ammunition each week, as well as all the required quantities of components.

Two types of shells, the 18-pounder and 25-pounder, were being manufactured in the existing plants when war was declared. But with the outbreak of hostilities, orders for many new types of ammunition poured into Canada from Great Britain.

As shell manufacture expanded, management also underwent an evolution. Originally under the Department of National Defence, administration of this key part of the war program was transferred to the Department of Munitions and Supply. Late in 1940, the Canadian munitions program was again expanded, and orders for shells were virtually doubled. Today, a large organization, the Ammunition Production Branch of the Department, consisting of seven divisions, is needed to supervise the vast ammunition program which embraces many types of shells, bombs and components, as well as filling operations.

After the fall of France, Canada was asked by the British government to create large capacities to manufacture shells, cartridge cases, fuses, primers and gaines, and to erect the necessary plants for the production of components.

Faced with this enormous undertaking, Canada turned to her engineering firms and manufacturers in the metal and allied trades. A survey undertaken by the Department of National Defence prior to the outbreak of war provided an up-to-date catalogue of facilities which could be changed over quickly to munitions production. Orders were placed with manufacturers, whose peacetime set-ups were most suitable for the switch to ammunition production.

In many instances, the contractors selected had suitable buildings which saved the government substantial sums of money, but rarely were suitable machine tools available to produce the supplies required. There was also a total lack of forging equipment.

But vast new plants have now been created and peacetime factories have spread themselves over a large area. All told, there are more than 130 plants engaged in making shells, and in producing the other components of a round of ammunition. Aside from the expenditure of private capital, the government has spent some $130 million in constructing plants for the production of ammunition, bombs, and mines, excluding expenditures on facilities to provide the raw materials for these plants.

Perhaps more than anything else, technical developments have been responsible for the spectacular growth of shell production in Canada. In the early days of the war, the importance of eliminating unnecessary and expensive machining for the inside of shells was realized, and the forged shell technique was adapted to almost every type. Designed in this country, the one-shot forging process proved an important development in shell-forging technique.

Another technical development of great value has been the single-purpose shell lathe, which can be manufactured in plants not designed for machine tool manufacture. Its fame has spread through the Empire and it is now regarded as standard shell-making equipment in Britain, India, Australia, and other countries.

Through these technical improvements, greatly increased production was possible with a relatively small amount of equipment.

From the very beginning, it was realized that manufacturing capacity for certain basic materials essential to the ammunition program would have to be augmented. This was particularly true of brass, which is used in tremendous quantities for cartridge cases for both gun and small arms ammunition. Two government-owned brass mills were put in operation during 1941, so that this metal would be produced at more than 10 times the rate existing prior to the war.

Small Arms Ammunition—At the outbreak of war, only one plant in Canada was producing service types of ammunition. This plant, the Dominion Arsenal, Quebec, had an output of about 750,000 rounds a month. When the emergency came, its old equipment, capable of turning out 50 million rounds annually, was promptly put into shape.

Another federal Arsenal, in Ontario, dormant since the last war, was again brought into production. Its function was to make brass cups to be finished and assembled into rounds of ammunition at the Quebec plant.

In addition, a private company, producing commercial ammunition at that time, had carried out development work in co-operation with defence authorities and had made sample lots of service ammunition.

Thus, two Arsenals and one private company comprised the total of Canada's small arms ammunition production resources in the fall of 1939.

After the fall of France, the Arsenals, previously operated by the Department of National Defence, came under the Department of Munitions and Supply. On October 1, 1940, the Arsenals and Small Arms Ammunition Branch of the Department was created.

With increasing ammunition orders from the United Kingdom came the need for expanding existing facilities at the two Dominion Arsenals and for bringing new units into production.

The Dominion Arsenal in Quebec is undoubtedly the oldest war plant in Canada. For many years, dating back well beyond the last war, it had been maintained in peace and in war to meet the needs of the permanent armed forces. Its function also was to keep abreast of new developments in munition making, and to provide a nucleus of plant, experience, and trained personnel that could be rapidly expanded in wartime.

In this plant, the entire manufacture is carried out from the production of materials and parts to the fabrication, filling, and assembling of the complete bullet. The plant has multiplied its output through mass production methods nearly 54 times since pre-war days. From 750,000 rounds, production has risen to nearly 40 million rounds a month of .303 ammunition of the ball, tracer, armor-piercing, and incendiary varieties. In addition, this Arsenal is producing various components, including quick-firing cartridge cases, primers, tubes, and boxes. It is one of the largest war factories in Canada, and at peak employed 12,500 workers, 60 per cent of whom were women.

At the Ontario Arsenal, an extensive program of plant expansion and installation of new equipment was undertaken to speed up production so that this Arsenal could

keep pace with schedules at the main plant. To do this, it was necessary to install electric melting equipment, and now virtually all the brass is poured from electric furnaces. Starting with an initial order to provide brass for 12.5 million rounds a month, this Arsenal now produces nearly 100 million brass cups each month, as well as a number of different types of projectiles.

Along with the development of the two Dominion Arsenals went the expansion and growth of the other plants engaged in turning out this type of war material. As the call came for more and more ammunition, factories were built across the Dominion.

Despite the large volume of output and the rapid expansion of facilities, the quality and accuracy of the production of the Dominion's small arms plants have rated high. The low ratio of rejects, and the high standard of the bullets have earned a fine reputation for this country.

AUTOMOTIVE VEHICLES

IN THE van of Canada's major wartime industrial program—a program which has helped to place the Dominion fourth among the United Nations as a producer of war supplies—stands the output of automotive vehicles.

More than 100 different types of motorized military equipment leave Canadian assembly lines at the rate of 3,500 units of mechanized transport and 300 fighting vehicles each week. The list includes universal carriers, scout cars, artillery tractors and trailers, troop and ammunition transports, service workshops, radio trucks, ambulances, and fire trucks. In point of value—more than $400 million in 1943—this output ranks as the biggest production job in the history of the nation.

The Canadian automobile industry, which even before the outbreak of hostilities had collaborated with Army

engineers in designing vehicles for military purposes, now extends over an area of more than five million square feet and employs in excess of 30,000 men and women.

To make possible the tremendous output and to conserve precious raw materials, the manufacture of passenger automobiles was stopped early in 1942. Since then, the entire industry has concentrated on supplying vehicles for Canada's armed forces and those of other United Nations.

In the last war mechanical transport was used largely for load-hauling behind the lines. The trend in post-war years, however, was towards vehicles of distinctly military design, for specific military requirements, and Canadian Army officials who watched British field trials and manoeuvres kept in close touch with the steady progress in mechanization. In the early twenties, for instance, the British Army developed a six-wheel load carrier which is still recognized as one of the best of its type. The patents were made available without charge to manufacturers throughout the Empire. Commercially impractical because of its heavy consumption of gasoline and tires, it was an outstanding example of a vehicle specifically designed for military use.

Experiments with new types of mechanized equipment especially designed for military use were also carried on by Canada's Department of National Defence, and each year representatives of the major automobile companies were invited to Petawawa to see and to discuss new developments. As a result certain distinctly Canadian types of equipment were produced in experimental quantities for the Canadian Army.

During the years prior to this war, Canada was groomed as the prime producer of mechanized equipment for the British Empire in the event of armed conflict. The policy of the Department of National Defence had been to standardize war equipment with the British War Office; in addition, the products of two Canadian automobile companies were in use in most Empire countries and the two firms agreed as early as 1936 to merge their resources for war production.

Consequently when war came, the government was able to embark on an extensive program of automotive production. The first order—for gun tractors—was placed late in the autumn of 1939. It was possible to call for materials in December and delivery of the first tractors was made in March, 1940. The gun tractor being a basic unit, it was a comparatively easy matter to expand from that to small trucks, then to larger units, and from there on to the many other types that now make up the varied list of Canadian motorized equipment.

Until the first military vehicles came off the assembly line, the nation's automotive program was based almost entirely on Canadian needs. But before production was fully in its stride, France had capitulated and the British armies were forced to leave nearly all their equipment on the beaches of Dunkirk. It was then that Britain turned to Canada to replace these catastrophic losses.

In July, 1940, the British placed in this country the first order, amounting to 7,000 vehicles, and from then on all limits were removed from the automotive program. But it was not only from Britain that the call for increased production came. Canada's armed forces were growing. The Dominion needed equipment for its own Army and so did other members of the Commonwealth and countries allied with the British Empire. Furthermore, the increased mechanization of armies had made it evident that Canadian industry would be called upon to meet unprecedented demands for transport. To accomplish this immense expansion, it was necessary to weld the automotive industry into a powerful war output source.

In peacetime, the industry is highly competitive. The ingenuity of production men is continually applied to the task of creating a better product at lower cost. No economies are too small to be overlooked, for in mass production a few cents saved on the cost of one part will amount to thousands of dollars in the course of a year. Trade secrets in this competitive business are jealously guarded.

Nevertheless, since the beginning of the war, the entire Canadian automotive industry has operated as a co-ordinated unit. Just as interchangeability of parts is a feature of the ordnance program, so interchangeability and standardization of design are important features of Canada's wartime automotive production. In complete contrast to peacetime competition, this free exchange of services and ideas is a primary element of the program and is a major reason for Canada's outstanding success in this field of war supply.

Production in Early War Years

During the first fifteen months of the war, nearly 80,000 Army vehicles were turned out. The period was marked by constant research, and the lessons learned after the Battle of France were applied to new designs. Gradually the problems of re-tooling for war were overcome; hundreds of unskilled workers were trained to new tasks, and scores of subsidiary firms swung into mass production. Canada was well on her way to reaching capacity output.

As old problems were solved, new difficulties arose. With such strategic materials as tin and rubber in short supply, with the United States facing war, and with Canada's output along other lines consuming enormous quantities of materials, all war industry faced supply problems. Without sacrificing quality, the automotive industry was asked to maintain production with less rubber, less brass and copper, and less alloy steel; to make the fullest use of its existing machine tools capacity.

Always conservation-minded, the industry met this challenge with characteristic vigor. Scores of eliminations and substitutions were evolved to save critical materials, to release scarce machine tools. As a typical minor change, one company saved 14 tons of rubber annually by substituting wood for rubber in the handle of an inspection lamp. A total of 7,000 tons of steel a year was saved by modifying the design of tire chains originally specified by Army authorities. The new technique of centrifugal casting enabled one company to

save 1,200 tons of metal a year in the manufacture of a small steering knuckle. Hundreds of design changes were effected on the universal carrier alone, with a reduction of 24 per cent in the cost of the unit.

Cost reduction was not the sole objective in these conservations, although the industry made steady headway in lowering costs by economical production methods in mass output. The principal aim was to spread available resources of critical supplies, machine tools, and skilled labor. The Department of Munitions and Supply and the Inspection Board of the United Kingdom and Canada both co-operated with the automotive industry in this program.

By 1941, Canada was, in effect, the prime source of mechanized transport for the British Empire. Vehicles were being shipped to Britain, South Africa, Australia, and other actual and potential theatres of war. Canadian-built trucks not only helped to bolster defences in the United Kingdom but they played an important part in the East African campaign, the re-conquest of Abyssinia, and the capture of Italian colonial possessions. More than half the load carriers used by the British Eighth Army in the African desert were made in Canada.

Production of armored vehicles, among them the armored scout car, armored reconnaissance car, and armored personnel vehicle, began during 1941. Some difficulty was encountered at first in bringing them into production. Time and time again test pilot models put on the proving ground were found to be deficient. But these faults were gradually corrected until today Canadian armored vehicles set a world standard for dependability and performance.

During that year the production of all types of vehicles rose steadily as new capacities came into operation and existing facilities were expanded. The number of wheeled vehicles and universal carriers turned out amounted to more than 120,000; in addition, 10,000 tons of armor plate, 56,000 bodies, and 336,000 spare tires were manufactured.

During 1942, all production records for the automotive and allied industries were exceeded. A total of nearly 200,000 vehicles, representing an increase of 60 per cent over the previous year, were delivered. All plants were running to capacity, handling not only standard models but new types of equipment designed to meet changing war conditions.

This large upswing in production was accounted for in part by the curtailment of passenger car manufacture and in part by the fact that the production capacity of a third Canadian automobile company was added to the nation's war facilities. This company, in addition to supplying standard load carriers, took over the manufacture of bridging equipment and Army machinery lorries and trailers. Its initial contract for these special types called for 3,500 vehicles of 35 different types. During the year, pilot models were built of all types, except two. In the latter, design changes held up their completion. The assembly of these highly complicated machines was a difficult job. Specifications were constantly being revised, hampering production. Nevertheless, before the end of the year some 1,200 units had been completed.

The 1943 over-all production continued at approximately the 1942 tempo, and in June Canada reached another important wartime milestone when the Dominion's automotive industry turned out its 500,000th motorized vehicle. By the end of 1943, close to 600,000 units of military transport and fighting vehicles had been produced.

As the war progressed and the enemy intensified its submarine activities in the Atlantic, a shortage of shipping imposed an extremely difficult problem. Every method of conserving shipping space was studied.

The original method used was to box a complete unit, which occupied 1,000 cubic feet. Later, by dismantling the wheels and cabs and packing them separately from the body, the shipping space was reduced to

800 cubic feet. By further experimentation it was found possible to pack a complete vehicle in less than 400 cubic feet.

Tire Production

When war was declared little preparation had been made to facilitate the production of military tires. Certain British specifications had been received here, but it was not until after hostilities started that any appreciable tooling-up program began.

At that time, the "runflat" tire, developed by the British War Office, was considered the most practical for military use. Three Canadian rubber companies undertook to produce a small number of them for urgent military needs and tests on vehicle chassis, and initial deliveries were made less than three months later.

As military requirements for motor vehicles expanded so did tire production. The "runflat" tire, which will run completely deflated on the rim even when punctured by gunfire, became standard equipment on all Canadian military models.

Until Malaya and the Netherlands East Indies fell into Japanese hands, there was plenty of rubber available for military needs, but when all shipments of crude were cut off, the conservation of rubber became a vital necessity. Every avenue was explored to reduce rubber consumption, and consequently the "runflat" tire, which requires more rubber than the ordinary pneumatic tire, was restricted in its uses. No spares were provided for overseas equipment using this type of tire, and all vehicles used in Canada were equipped with conventional or highway-type tires. In addition, the skid depth of all cross-country tires was reduced.

With these savings accomplished, other fields of retrenchment were investigated. As one instance, metal bead locks were designed and approved for use in "runflat" tires, replacing the rubber bead spacer formerly used. This substitute represented a saving of nearly seven pounds of crude rubber for each tire assembly.

As stocks of crude rubber decreased, the need for a substitute became apparent and Canada decided to enter the field of synthetic rubber production. The construction of a plant began in the middle of 1942.

A fuller discussion of the rubber situation is contained in the chapter, "Rubber."

Armor Plate

Following the expansion of the automotive industry, Canada embarked on a program of armor plate manufacture. Had this program not been undertaken it is doubtful whether Canada's contribution to the United Nations would have been as effective as it is today, because prior to 1940 all armor plate or bullet-proof plate was imported from the United States or Great Britain.

Before 1941, armor plate and castings were being produced at the rate of 50 tons a day. A study of requirements showed that the output would have to be increased to double that quantity, and steps were taken to expand existing plant facilities. Since then, production has risen steadily to more than 4,000 tons a month, and by mid-summer of 1942 there were sufficient stocks of armor plate on hand to meet existing requirements. Output was then decreased to approximately 2,000 tons monthly, and the capacity thus released was diverted to the fabrication of mild steel plate for shipbuilding and other pressing programs.

Tanks

Until the present war, Canada had not built a tank. Its manufacture has little in common with other types of military equipment, and no peacetime vehicle has any relation to it.

When the tank program was initiated, it was thought that the automotive industry would undertake the task. However, these companies were rapidly converting to mass production of Army vehicles and spare parts. Instead, two locomotive works were selected to undertake the program. They had trained engineers

and technicians, the heavy equipment needed to handle armor plate and castings, and neither plant was operating at anything like full capacity.

In June, 1940, a contract was placed for 300 Valentine tanks. This was later increased until a total of 1,420 had been ordered. The first vehicle was delivered one year later.

The Valentine, so called because the first was completed on February 14, is a medium light tank of British design. Powered by Diesel motors, the body is made of armor plate, riveted and bolted, and the rotating turret may be operated either by hand or by electrical control. In reality, it is a giant mechanical ferret capable of burrowing its way through a brick building. As big as a living-room in an ordinary house, it is able to climb steep ascents, ford streams, and rip through barbed wire entanglements or whatever ordinary defence works may be thrown up in its path. There are more than 40,000 parts, exclusive of armaments, in a single Canadian-built infantry tank. Production in Canada was terminated on completion of contracts and final shipments were made in May, 1943. Of the 1,420 Valentines produced, only 30 were retained for training purposes in this country; the balance being shipped to the Soviet Union.

Among the first pieces of armament to be produced in Canada from United States specifications, the Ram tank is a cruiser type built for the Canadian Army. Nearly twenty feet in length, it weighs as much as a railway freight car. It can proceed over all kinds of terrain from swamps to rocky and irregular ground. Its Whirlwind engine, which develops as much horsepower as several large, modern automobiles, is capable of propelling its great bulk over obstacles and up steep hills. It is heavily armed with machine guns and a cannon capable of great offensive power.

By the middle of 1942, Ram tank production was terminated after nearly 2,000 had been built. It was replaced by the M-4, a standard type for United States,

British, and Canadian armies. However, the trend in offensive warfare required self-propelled mounts, and production of the M-4 was discontinued at the end of 1943.

Motor Vehicle Control

In peacetime the automobile industry was one of the five largest Canadian industrial enterprises with many millions of dollars invested in plants and equipment. Supplies and materials to feed this vast industry came from hundreds of subsidiaries, employing thousands of employees. A nation-wide organization of dealers and distributors handled the finished products, and an army of mechanics kept these products in running order.

To divert the facilities of the industry from civilian to war needs and to arrange for the maintenance of essential passenger cars and trucks, a Motor Vehicle Controller was appointed on February 13, 1941.

Three major problems confronted the Control: The provision, as quickly and economically as possible, of war supplies; provision for maintaining the supply of essential civilian requirements; and the determination of the rate at which conversion from peacetime to war-time needs could be accomplished so as to conserve materials, manpower, and manufacturing facilities.

Early in 1942, the production of passenger automobiles was stopped. To take care of the needs of physicians, nurses, firefighting and police departments, and others in essential classifications, 4,500 new cars were set aside for a government "bank."

Cars from this reserve pool are released only for essential purposes on a permit from the Motor Vehicle Control. To date, about 800 cars have been released from the "bank."

By January, 1942, demands from the armed forces had increased to a point where drastic curtailment of civilian truck production became necessary. A ban on the making of trucks and buses, except by permit, went into effect on March 14, 1942.

However, the expansion of business activities and increased transportation resulting from the war program made it necessary to meet the needs of essential commercial firms for transportation equipment. Trucks and equipment were diverted from non-essential to essential work, and restrictions were imposed on trucking and delivery services.

This diversion met most of the needs during 1942, but it was obvious that a broader program would have to be developed in order to provide the units needed each year to meet civilian requirements.

A careful study was made of the specifications of vehicles being produced for military equipment, and models were selected of such basic design that they would meet civilian requirements. Manufacturers were then permitted to divert from military schedules certain models which were to be stripped of all military equipment and produced as commercial units. Thus all new trucks for civilian purposes had to be released at the expense of the armed forces. Prospective purchasers had to prove their essentiality to the Motor Vehicle Control before a truck could be released.

A forecast of civilian needs during 1944 shows that 8,400 trucks will be required, and these will be manufactured and released in the same manner.

By April, 1942, orders for replacement parts and accessories for the armed forces had so taxed the available manufacturing capacity that it became necessary to control the production and distribution of parts for civilian use. A ban on the production of non-functional parts went into effect and quotas were established permitting the production of functional parts for passenger cars and light trucks at the rate of 70 per cent of the previous year's output. On the other hand, to keep commercial vehicles on the road, parts for essential trucks and buses were released on an increased scale.

On January 1, 1944, the list of functional parts and accessories which could be manufactured was increased. In addition, the scope of the new order was limited to

parts made of rubber, plastics, wood (except wood pulp products), or metal, instead of covering all materials as in the former order. Among other items, the new order permitted resumption of the manufacture of tire pumps.

Before the war, Canada exported a large number of motor vehicles to foreign countries. Before the ban was placed on the production of passenger cars and trucks, the Control requested that Allied countries supply a definite outline of their requirements. Requests from these countries were studied, and some items were included in the manufacturers' schedules before the making of civilian motor vehicles was stopped.

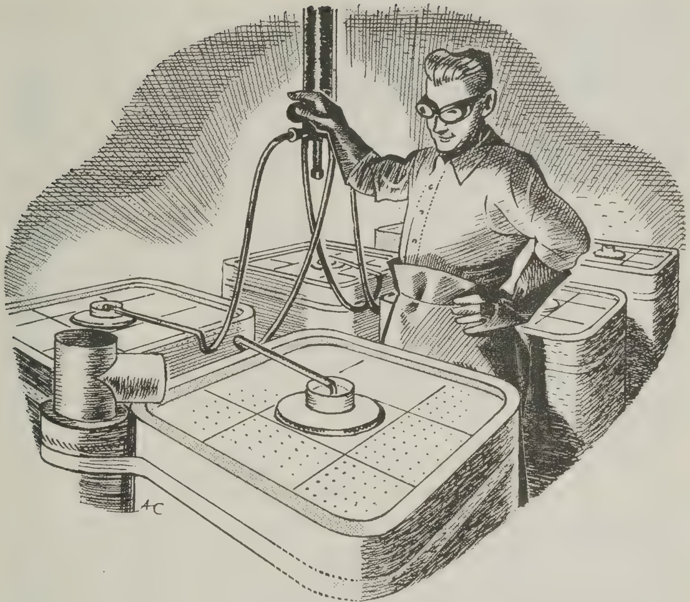
With the ban on the production of new vehicles came another problem to be solved at the same time. In peacetime it had been common practice among operators to run their vehicles with the minimum of service and repairs. Instead of repairing an old truck, they had found it easier to replace it with a new one.

A reversal of this procedure became necessary when no new cars, trucks, or buses were being made. The result was a need for an increased number of mechanics to keep vehicles in good running order. Hundreds of repair men had enlisted in the armed services or had gone into war industry, leaving insufficient mechanics available in garages and repair depots to take care of the increased demand for their services.

To meet this problem, the Motor Vehicle Administrator for the Wartime Prices and Trade Board established a "preferred list" to assure that the restricted repair facilities would give preference to repairing of motor vehicles performing essential duties. This enabled repair depots doing essential work to be given a labor priority rating by National Selective Service. To conserve man-hours in the manufacturing of the vehicles, the Motor Vehicle Control also ordered that all new motor vehicle chassis and bodies be painted one standard color.

By the beginning of 1943, the demand for trucks to work on the Alaska Highway reached serious proportions. At one time, there were more than 2,000 applica-

tions for permits to purchase new trucks for hauling on the highway. In view of the fact that the 1943 truck production program called for the manufacture of only 3,600 trucks for civilian use in the entire Dominion, the Control took steps to solve the problem. Arrangements were made with the United States to supply the necessary transport and supply replacement parts from U.S. sources and, by the late summer, the demand for new trucks for operation on the Alaska Highway had virtually ceased.



CHEMICALS AND EXPLOSIVES

ON THE white-smocked chemists of Canada rests much of the responsibility for the successful outcome of the war. Without them Canada's ammunition-filling program, on which the United Nations depend so largely, would not have been possible. Without them this country would not be producing plastics, paints, dopes, varnishes, grease-removers, medicinal preparations, and thousands of other essential war items. Without them the prospect of "Made-in-Canada" substitutes for rubber would have been merely a dream.

One of the largest, most intricate, and most interesting of all the war programs in Canada has been the

mushrooming of half a hundred chemical and explosive projects scattered across the country. Their construction and operation required higher skill, greater learning, and wider experience than perhaps any other industrial war program. But at the same time the chemicals and explosives program has received less acclaim than the other industrial efforts of this country.

Two factors have been responsible for the lack of acclaim. In the first instance, security, safety, and other considerations often necessitated locating the plants in more or less remote areas; and secondly, the modesty of the scientist combined with his inability to express himself other than in polysyllables made it impossible for the layman to realize the extent of the operations, and the extent of the scientific advances achieved by Canada.

At the beginning of the war, the problem which lay ahead of the Department was the construction and administration of five explosive plants, each to cost from $2.5 million to $18.2 million; four chemical plants to cost from $1.3 million to $9.1 million; the erection of four shell-filling plants to cost from $6 million to $19 million; and the erection and later the supervision of more than 40 subsidiary or complementary projects, including nine magazine depots, each involving expenditures running up to $1 million. Of these fifty projects, all long since completed, only nine are privately owned. The remainder are owned by the people of Canada.

In some instances, two or more of the foregoing undertakings are located on the same property and their operations are co-ordinated to form virtually one project. But, they are individual plants and in some instances their ouput is used both in the chemicals and explosives program and also for other essential war or civilian purposes.

The fact that one of the ammunition filling plants occupies 450 separate buildings scattered over an area of more than 5,000 acres gives an idea of the magnitude of some of the projects. The plant has its own railway, a fleet of trucks, and living quarters for hundreds of employees, together with a recreational centre, a post

office, a hospital, and a hotel. All told these new plants cover an area equal to that of the city of Montreal. The whole program involved an expenditure of some $150 million, on properties owned by the Dominion, excluding the $48 million synthetic rubber plant on which the preliminary studies were carried out by the Chemical and Explosives Branch of the Department.

As the program rapidly evolved in the hectic days of 1940-41 three dozen chemical plants were under construction at once. When later they came into operation, the flow of chemicals into explosives, and the final output of explosives, had to be balanced with the production of shells, percussion caps, gaines, fuses, primers, bombs, flares, mines, grenades, and pyrotechnics, all of which utilize varying types of explosives, chemicals, and the other materials, such as magnesium, which entered into the program.

During the past two years most of the plants have been in operation. Fuel requirements have cost more than $4 million monthly. Electric energy in one month has cost $354,000. As many as 50,000 men and women have been employed.

During the first two years of war when the major part of the construction work was in progress, extensive and successful chemical research was carried out in a variety of fields to meet the urgent need for modified types of explosives, and for the means of producing British ammunition and explosives from the raw materials and manufacturing processes obtaining on this continent. At the same time the work called for a variety of other studies to meet the new problems involved. While the engineers designed the more than 100 steel boilers required to meet the specific needs of the new plants, physicists studied the intricacies of the behavior of static electricity—always a major hazard in any explosives project. At the same time, a vast amount of other effort was expended on labor relations, purchases, by-products, medical services, safety and security measures, and employee housing—for some of the plants were located in out-of-the-way places.

The program was not merely confined to the production and utilization of the chemicals required for explosives. There were the techniques of shell filling to be learned—and learned rapidly. Men had to be sent to England for this purpose. Again, the production of a wide variety of chemicals was required both for use as intermediates in the program and for other purposes.

In addition to the chemicals usually associated with making explosives, such as glycerine, sulphuric acid, toluol, cellulose, nitrates, and ammonia, a dozen other chemicals had to be manufactured for use either in conjunction with these chemicals or for special explosive and other purposes.

Alkylate had to be provided for high-octane gasoline. Hexachlorethane was produced for smoke bombs and smoke shells without which modern warfare is impossible. Other chemicals produced included carbides, phosphorus, alcohols, acetone, aniline and phthalic anhydride.

The foregoing summarizes briefly something of the scope of the program and indicates some of the problems inherent in it. Had the technicians who initiated and carried through these undertakings originally grasped what was expected of them in a brief 24- to 30-month period, they would have staked their professional reputations on the impossibility of its successful fulfilment. Thanks, however, to the brilliance and the conscientious endeavor of Canadian chemists the program was carried through. Its achievement would have been impossible had not Canadian universities for many years been turning out competent chemists and engineers. Thus those directing the program had a reservoir of trained men eager and ready to assist in this vital phase of Canada's war effort.

As more and more technical men joined the ranks of those engaged in it, the program gathered momentum. At the first of the shell-filling plants, production began eight months after construction had started. At the next two similar projects, production began six months after the initiation of construction. While at the fourth shell-filling plant only four months elapsed between turning the first sod and initial production.

The story of the development of fuse powder manufacture provides a sidelight on some of the problems faced by those responsible for the program. Canadian manufacturers had much knowledge regarding the manufacture of gunpowder, the chief ingredient in fuse powder. But the art of fuse powder production was unknown in Canada. Even in England the craft was so restricted that only a few small plants existed. There the powder was chiefly made with charcoal produced from dogwood, or alder-buckthorn. But these woods are not native to Canada, although there were a few small stands of dogwood spread from trees which probably had their origin in Britain. When it first became necessary to manufacture fuse powder in Canada, much timber cruising was required to locate adequate stands of the proper species, which in Canada grows in swampy or marshy land. Many, many wet miles were tramped before the dogwood was discovered. The trees were immediately harvested against loss or possible sabotage, and sent to the fuse powder plant where the wood was stockpiled until required. Later, as a result of intensive research, alternative domestic woods were discovered from which suitable charcoal was produced.

As a result of all these efforts, Canada had filled to the end of 1943 some 100 million rounds of gun ammunition, smoke boxes, pyrotechnics, grenades, mines, depth charges, flares, bombs, and kindred items, as well as billions of rounds of small arms ammunition. The total production of filled gun ammunition on the same date stood at 59 million rounds. In addition there has been a very substantial output of filled and unfilled cartridge cases and shells, filled detonators, filled fuses, and other ammunition components.

Canadian explosives are used on every fighting front in myriads of forms. For example, Canada manufactures and fills some 25 types of gun ammunition including bombs and grenades. There are also produced many varieties of small arms ammunition, mines, depth charges, and similar missiles, as well as 70 basic types of pyrotechnics including flares and practice bombs.

At its peak, production was running at the rate of some 10,000 tons of chemicals and explosives each week. All told, chemicals and explosives produced since the beginning of the war total more than one million tons.

Concerning the development of new processes and products, first mention should be made of the work of a departmental chemist whose studies resulted in the immediate introduction in Canada, and later in the United States, of a more rapid and more efficient means of producing RDX, the new super-explosive. In addition, Canadians developed new uses and methods of employing this, the first major advance in explosives made in many years.

Working under the aegis of the Department, Canadian chemists developed methods of utilizing wood pulp instead of cotton linters in the manufacture of nitrocellulose. This discovery reduced manufacturing costs.

A new technique was also developed for the production of TNT from existing equipment. This process change was adopted immediately in Canada and later in the United States, and substantial savings were effected both in capital outlays and in operations.

Owing to the increased food requirements of the United Nations, early in 1943, an urgent need developed for larger supplies of nitrogenous fertilizing material. Ammonium nitrate was known to have the necessary nitrogen, but it absorbed water readily and caked into hard masses. In six months Canadian chemists overcame this difficulty, and in July, 1943, the Canadian government was able to offer the Combined Food Board of the United Nations a large output of conditioned nitrate fertilizer to be distributed in the United States, Canada, and the British Empire. From this development, Canadian farmers will continue to benefit after the war.

Various explosives and propellents have been developed to meet the needs of the individual Allies. Canadian chemists have contributed explosives used in various types of rockets.

But for obvious reasons many of the brilliant accomplishments of the Canadian research workers and chemical engineers cannot be described in detail until the end of the war. Their war work will make a decided impact on the peacetime economy, for the industrial age has long since turned into a chemical age, and the war has turned Canada into one of the major producers of chemicals. With this in mind, in developing the program consideration was given to the post-war value of the facilities created. While the explosives plants may have little salvage value, there should be a substantial value in the chemical plants which have been located and designed to meet post-war conditions.

The work of getting the explosives undertakings rapidly into production involved more than mere brawn and brains. Men risked their lives and their reputations to speed production. Rapid inspection of highly sensitive explosives was required in order not to delay production. But adequate testing could not be conducted at the new plants, and on the other hand ordinary methods of shipping were slow. Thus on occasion scientists wrapped deadly fulminate in a blanket and themselves conveyed it either by train or by automobile. Their tests completed, they immediately telegraphed the results to the plant. Such steps were never suggested, condoned or even known officially. They were taken because men were willing to risk their lives to assure munitions to our armies abroad. These men may now have grayer hair, but they also have the satisfaction of knowing that they made a vital contribution to the forces of freedom.

Administratively, this great program was carried out by three agencies: First, the Chemicals and Explosives Production Branch undertook the basic scientific studies and formulated the basic plans.

Second, the construction and operation of the properties were administered by Allied War Supplies Corporation, a Crown company incorporated for this purpose.

And third, the Chemicals Control regulated the supply and distribution of chemicals in Canada.

The Chemicals and Explosives Production Branch determined what was to be made, how much, and where. Once these factors were decided, it was the responsibility of Allied War Supplies Corporation to initiate negotiations for the construction and operation of the plant. The actual management of each property was placed in the hands of a contractor with previous experience in similar fields of endeavor, and with an efficient and reliable record. The contractors operated the plants on a management fee basis.

Allied War Supplies Corporation

Incorporated on July 23, 1940, Allied War Supplies Corporation is responsible for the administration and integration of a vast group of industries. Huge stockpiles have been built up and the output of the plants under its administration has been correlated with current war requirements.

The corporation administers more than 40 projects on behalf of the Canadian government, all of which have been constructed since the beginning of the war. In addition to these projects there are a few chemical undertakings owned by the people of Canada, which are correlated with the larger program through the Chemicals and Explosives Production Branch.

Allied War Supplies Corporation administers the operation of all the ammunition-filling plants owned by the Crown, save for the arsenals which fill small arms ammunition. It is responsible for the production of all explosives in Canada, together with a substantial complementary production of chemicals and other materials used in Canada and also exported in volume to Britain and the Empire, and to the United States.

Every project administered by this Crown company has not only been able to reach scheduled production but has attained an output substantially higher than rated capacity. This satisfactory showing stems from efficiency in operation and from technical and scientific advances worked out, either in the plants or by research workers. For example, the advances and improvements in TNT manufacture have enabled the plants virtually to double their production from existing facilities.

Chemicals Control

During the early months of the war, the problem of supplying chemicals for the war program rested on the shoulders of the Chemicals and Explosives Production Branch. But early in 1941 it became apparent that shortages of chemicals both for war and civilian purposes made necessary a closer regulation of supplies. In July, 1941, a Chemicals Controller was appointed.

The functions and problems of the Chemicals Control differed somewhat from the other controls in the variety and ramifications of its operations. The range of chemicals in a modern economy and their various uses have become illimitable, and thus it was necessary that the Control obtain jurisdiction over the raw materials covered by as broad a definition as possible. Within the definition are included all the acids and other industrial chemicals and, in addition, such commodities as molasses, plastics, pigments, essential oils, albumens and other materials which may be products of a chemical change but are not normally regarded as chemicals.

Since its inception the Control has broadened in scope until it now takes in more than 300 items ranging from quinine, dealt with in ounces, to soda ash and sulphuric acid, dealt with in hundreds of thousands of tons.

The operations of the Control were the more difficult in that the importance of certain chemicals to the war program was not generally realized. For example, coal tar is essential in the production of aluminum, ferro-alloys, abrasives, lubricating oils, resins, and protective coatings for military vehicles.

Similarly, alcohol has been needed in the manufacture of styrene, an essential ingredient of buna-S synthetic rubber. This requirement made it necessary to divert more than half the Canadian alcohol production capacity and, coupled with the continuing demand from other essential industries, resulted in the complete curtailment of the production of potable alcohol.

During its first year's operation, the Control obtained on loan the services of a group of distinguished industrial chemists, each of whom was a recognized specialist in his field. Important steps were taken more adequately to control and direct the flow of sulphuric acid, chlorine, glycerine, soda ash and other chemicals.

A close relationship has been established by the Control with the chemical division of the War Production Board in Washington, and Canada has received equal treatment with the United States in the distribution in this country of chemicals manufactured in the United States.

Much of the allocation and other control work has been accomplished without issuing formal orders.

In addition to providing for the needs of war industry, the Control latterly has been able to allocate for civilian use some of the production of government-owned chemical plants erected to meet war needs.

The following paragraphs give a brief summary of the Control's activities covering some of the more important groups of chemicals:

Alcohol

On November 1, 1942, the Chemicals Control, in order to meet war and essential civilian needs, took over the total production of all Canadian distillers. The distillation of high proof alcohol for potable purposes was discontinued at that date.

Distilleries which had been manufacturing alcohol from molasses were given assistance in changing their plants in order to use grain as a raw material and to increase their productive capacity. Because of the difficulty of transporting molasses from the West Indies, the use of wheat became essential.

The production of industrial alcohol in Canada is adequate for all domestic requirements and large quantities have been shipped to war industries in the United States.

Chlorine

Chlorine is widely used industrially. Increasing demand during the war came largely from its use in degreasing compounds employed in metal-working plants and from the immense demand for hexachlorethane, the smoke-producing chemical so widely used by the three services and without which many operations would be impossible.

Canada entered the war with an excess chlorine production and until 1943 was able to export to the United States. Although an additional plant was brought into production last year, the chlorine imports from the United States exceeded the exports in 1943.

The only restriction on the use of chlorine followed the issuance of a U.S. order reducing the brightness of certain pulps. A similar order was issued in Canada.

Chlorinated solvents were among the first materials to require the attention of the Chemicals Control. They include carbon tetrachloride, trichlorethylene and perchlorethylene.

These chlorinated solvents find their chief use in metal cleaning, fire extinguishers, dry cleaning, various chemical processes, and in small-package distribution as spot removers. Carbon tetrachloride on evaporation produces a heavy blanket of non-inflammable vapor and is used extensively in firefighting. Trichlorethylene finds its greatest use in metal degreasing and is used also as a solvent in many chemical processes. Perchlorethylene is used chiefly as a dry cleaning solvent in the smaller plants where the use of a petroleum solvent, together with the necessary fire prevention facilities, would be uneconomical.

In the autumn of 1941, the demand for trichlorethylene increased greatly owing to the demands of war industries. During the first six months of 1942 the Control carried out a complete survey of all installations in Canada to determine the essential demand for degreasing, the possibility of substituting other degreasing agents and also the possibility of adopting conservation measures.

Acting on information from the survey, the Control reduced the total monthly consumption of trichlorethylene by almost 20 per cent between December, 1941, and the year ended June, 1943. This enabled the existing solvent producing facilities and the available chlorine supply to meet the demand while additional facilities were being provided.

During the second half of 1943 consumption increased, but production kept pace with the demand.

Arrangements were made to supply the dry cleaning industry with trichlorethylene, which requires only half the amount of chlorine used in the manufacture of perchlorethylene. Because the trichlorethylene is not as satisfactory a solvent, some of the larger perchlorethylene users immediately began using a petroleum solvent and this reduced the demand for trichlorethylene.

Carbon tetrachloride is imported from the United States. During 1942 a shortage occurred and deliveries in the United States for less essential uses, such as dry cleaning, metal washing, and packaging, were restricted to 50 per cent of normal. During 1943 in both Canada and the United States the demand for carbon tetrachloride increased so greatly that all its non-essential uses were prohibited. The carbon tetrachloride situation remains critical.

Coal Tar

Late in 1941 it became apparent that there would be a shortage of coal tar for the production of coal tar pitch and pitch coke required in the aluminum, electrochemical, and abrasive industries. At that time some five million gallons per year were being used as a fuel in the furnaces of a steel plant in Hamilton. At the instance of the Control, the company agreed to divert its supply to the tar distilling industry and to employ other fuel in its open hearth operations.

The additional supply so obtained temporarily met the need. But soon the supply became insufficient, and an order was issued prohibiting the use of coal tar in the construction or maintenance of roads and airport facilities. This order made available an additional six million gallons per year for essential use.

These savings, together with imports of coal tar and coal tar products from the United States, provided an adequate supply in Canada during 1943.

Coal tar acids are distilled from coal tar. They include phenol and its cousins, such as cresol, cresylic acid, and xylenol.

These materials are of strategic industrial importance. They are used, for example, in making plastics, in oil refining, in disinfectant manufacture, and as flotation agents in mining operations. Early in 1942 shortages developed, and it became necessary to place all supplies on an allocation basis. The position became worse as time went on and, in some instances, the use of coal tar acids was prohibited for certain purposes, particularly where substitutes could be obtained.

Through arrangements made with the United States for the importation of phenol, the Canadian plastic industry has been able to attain and maintain a high rate of production. In return, Canada has been able to export cresol to the United States, where there has been a shortage of all coal tar acids during the past two years.

Ethylene Glycol

The two principal uses of ethylene glycol are for commercial explosives and automobile anti-freeze. The chemical is not manufactured in Canada. Reduced supplies in the United States necessitated severe restrictions on its use as an anti-freeze. A permit system was introduced in order to meet the 90 per cent reduction in supplies available to Canada.

Glycerine

To meet the demand for glycerine for the manufacture of cordite, it became necessary to bring in imports from the United States early in 1941. With similar demands from the United Kingdom and later from Russia, the glycerine situation became critical in all the Allied countries by the middle of 1941.

In that year, the Controller restricted the civilian use of glycerine to 70 per cent of the 1940 level and later restricted it to 40 per cent. At the same time, efforts

were made to increase production by recovering glycerine previously wasted, and by improving the efficiency of existing plants.

The supply of vegetable oils from the East Indies for soap manufacture was cut off early in 1942. At that time it was felt that it might become necessary to produce glycerine by other methods. However, the efforts made to secure an increase in the supply of fats and oils from new and existing sources enabled the Dominion to pass satisfactorily through the crisis. At the beginning of 1944, glycerine was in much easier supply, and all restrictions were removed.

Lime

Some 30 or more lime plants are scattered across Canada. They are located adjacent to limestone quarries whence the stone moves to the kilns.

Each quarry produces a different variety of limestone and each variety has its own industrial use. Thus, much skill is required in placing the various grades with the proper industries.

At times lime has been in short supply for the building trades and for agriculture.

Pharmaceuticals

Under the jurisdiction of the Chemicals Control, the supply and distribution of pharmaceutical chemicals in Canada have improved. Two drugs in particular demonstrate the methods employed.

In 1942 salicylates, formerly imported from Britain, became increasingly scarce until the supply position in Canada was threatened. At the request of the Control, the U.S. War Production Board established a quota of salicylates for Canada. The drug was then allocated in Canada to suppliers on the basis of 1941 purchases.

In October, 1942, the distribution of this chemical was about 60 per cent of normal. One year later the figure was 80 per cent, and during 1943 sufficient stocks were available to permit the release of extra quotas on two occasions. Further relaxation of the control of this chemical is in prospect.

Citric acid also formerly came from Britain, but is now obtained from the United States on allocation by the War Production Board. Consumers have received a steady supply on a quota basis. Stocks have increased and it is expected that the restrictions may be relaxed. Three months after the occupation of Sicily 100 metric tons of citric acid reached Canada from that Italian island.

With the capture of Java by the Japanese early in 1942, supplies of quinine were cut off. All Allied countries had to depend on stocks on hand for malaria treatment. Some substitutes were available, but were not entirely satisfactory. Upon the recommendation of the Control, the Department purchased all stocks of quinine in dealers' hands to meet the future requirements of the forces.

In 1943, 17,000 circulars were mailed to physicians and drug stores throughout the Dominion asking for donations of any small amounts of quinine on hand. In addition, through the press and radio, the public was asked to contribute any quinine available. The public responded generously.

Plastics

From a scientific wedding of the chemical constituents of coal, air and water; from cow's milk; from limestone, natural gas, and salt; from wood and acetic acid or acetic anhydride; from carbolic acid urea and formaldehyde; and from various other sources, scores of plastics, many of them fresh from the magician's wand of the wartime chemist, are doing their bit in the fight for freedom.

Not only as substitutes for such scarce materials as metals, rubber, and silk, but also as a means for speeding up the production of complex shapes and parts, plastics are being used so extensively that some are now almost as scarce as the materials they are intended to replace. One example of this shortage is nylon. Instead of being used for women's stockings, it is being woven into parachutes.

Before they become periscope housings, warplane windshields, bullet tips, army badges and buttons,

instrument panels, or any of tens of thousands of shapes, parts, and articles now made synthetically, most plastics are in powder form. Squeezed into moulds under tremendous pressure and at a high temperature, the powder undergoes great physical changes and emerges as the finished article or part. Instead of being a powder, some plastics are in liquid form, and their treatment differs somewhat.

An instance of the development of plastics is the manufacture of raincoats for Canada's armed forces from limestone, coke, and salt. The plastic powder is transformed into a polymerized vinyl resin, and this resin is dissolved into a suitable solvent, pigmented to give it the navy blue, khaki, or air force blue color, and plasticized to make it flexible. The coating composition is then applied to a cotton fabric and the material is ready to be used as waterproof sheeting or turned over to a tailor to be made into raincoats.

In February, 1942, the Chemicals Control established a Plastics Advisory Committee. Throughout the war the Control, aided by this committee, has been successful in meeting virtually all the demands for most types of plastic materials including elastomers, a generic term for certain thermoplastics having an amazing number of applications including shoe soles, raincoats, protective waterproof clothing, upholstery, flexible tubing and innumerable other uses.

In March, 1942, steps were taken to assure a continuity of supply of phenol formaldehyde to the moulders who, at that time, could not meet the demands for war industry, let alone the demands for essential civilian purposes. The situation was met by restrictions, and by expansion of the sources of supply. Canada now supplies only about two-thirds of Canadian requirements of phenol formaldehyde compounds and the balance is obtained from the United States.

Soda Ash

Soda ash is known to the housewife as washing soda. It is a water softener, a flux in smelting, and is used for many purposes in the manufacture of aluminum, paper, soap, textiles, glass, and oil refining. It is used also in

the preparation of leather and for a hundred and one other industrial purposes.

Thus soda ash ranks with sulphuric acid as a basic industrial commodity. Its uses are almost as varied as those of sulphuric acid, and its rationing would present equal difficulties. Consumption in Canada is at a rate of two and a half times that of 1939.

Before 1941 there was only one plant in Canada manufacturing soda ash. Production at this plant was stepped up three times. Increased imports from the United States and Great Britain were also arranged.

Solvents and Lacquers

In May, 1941, it became apparent that strict control over lacquer solvents was essential if direct war requirements were to be met. Consequently, these chemicals were placed on a strict allocation basis and imports were later made subject to permit. To date it has been possible to meet all essential war requirements, but the situation at the close of 1943 was still critical.

Some solvents have been made available for civilian uses, but distribution has been on a very limited quota basis.

Sulphuric Acid

Sulphuric acid was one of the first materials requiring action in the early days of the Chemical Control. Explosive plants were coming into operation and additional acid was required for other war industries or for essential civilian purposes. Some thought was given to rationing, but sulphuric acid is one of the most difficult materials to allocate, entering as it does into almost every industry. So, instead, measures were taken to augment the supply.

At one time, in the explosives industry large quantities of weak and impure sulphuric acid were allowed to run to waste. However, new methods were introduced and the weak acid was reconcentrated for re-use in explosives plants; and in addition, some of the waste

acid was used in making fertilizer. Existing facilities for making sulphuric acid were doubled in capacity and, at the same time, the Control arranged for the transportation of acid from British Columbia to eastern Canada.

During 1943 the demand eased somewhat and Government-owned plants are now diverting substantial quantities of sulphuric acid to fertilizer plants and to other civilian industries.

CONSTRUCTION

IN THIS war the Canadian construction industry has grown to stalwart manhood. It has tackled and licked the biggest job it ever faced. Since the Nazis first crossed the Polish frontier in 1939, the Canadian government has ordered construction projects, and equipment installations, to a total value of approximately $1,381,300,000, or an average investment of about 34 War Savings Certificates for every man, woman, and child in the nation.

The $1,381,300,000 total comprises commitments of $755.4 million for new or expanded industrial production facilities (including $57.3 million of contracts awarded by the Defence Projects Construction Branch), $393.7 million for barracks, hangars, and other projects for the armed services ordered by the Defence Projects Construction Branch, $78.3 million for projects of Wartime Housing Limited, $23.2 million for miscellaneous capital

investment, $50 million for airports and runways, and $80.7 million for miscellaneous defence works. In addition, large sums have been spent by private companies for industrial expansion to undertake war contracts.

Construction has been for many years one of the sturdy industries of Canada. At the beginning of the century, it was a husky youngster. Settlers and capital were rushing in. Railways were under construction. In 1912, building contracts exceeded $453 million, but the war of 1914-18 brought sharp declines. It was a war in which Canadians did much fighting, but relatively little building.

This is a different war. The need for men has not lessened, but the need for machines of war is so much greater as to justify no comparison with the first Great War. To turn out such machines, through all the varied processes from obtaining the raw material to packaging the final product, calls for many hundreds of new plants and enormous quantities of new equipment. And because, for the first time in more than a century, Canada's own shores were seriously threatened, a new and unfamiliar need arose for defence works built on Canadian soil.

Since the beginning of the war, more than 701 hangars and hangar-type buildings have been erected. In all, 195 airfields have been built. Paved runways on these fields equal a highway extending from the Atlantic to the Pacific and back as far east as the Rocky Mountains. The construction work for the Commonwealth Air Training Plan alone has involved the erection of more than 5,506 buildings. Aircraft plants employing over 100,000 men and women have been built up almost from nothing since the outbreak of war. Shipbuilding and munitions plants, drydocks, and other ship repair facilities, and coastal defence batteries have sprung up. Millions of dollars have been spent on power development and transmission lines. A $48 million plant capable of turning out sufficient synthetic rubber to meet all our wartime requirements has been erected. More than 17,300 dwellings for war workers have been built in areas where congestion was acute. The tremendous

construction work involved in the expansion of the chemical, mineral, and metal working industries is covered in the appropriate chapters of this volume.

The men of the industry have done not only a big, but also a courageous job. In the depths of winter, with its winds and sub-zero weather; in the height of summer, with its heat and humidity; in snow or storm, in slush or drought, construction gangs have stayed on the job. In terms of human courage and endurance, there is no measure of their effort. In terms of contribution to the war program, it adds up to a shortening of the war by many months, and the saving of thousands of human lives.

When the full record of Canadian wartime achievement is revealed, stories of the zeal and determination of these construction men will provide an important chapter. Time and again they have clipped months from tight construction schedules. Giant new plants that would have taken several years to build in peacetime, have been completed in half the time under war pressure.

The largest explosives plant in Canada is only one example of a high-pressure war job. The first sod was turned in February, 1941. By September of the same year, construction had advanced to such a point that operations could be started. In January, 1942, the whole, vast project was virtually completed. What had once been a bush lot, nine miles square, had become a giant war factory, comprising 450 separate buildings.

Historical

The first few months of the war saw little construction activity. The fall of France found the industry well prepared. While the volume of business during previous years had not been large, it had been sufficient to keep plants and equipment in being. Trained staffs were ready. Raw materials were then available. Rapid progress could be made.

The Defence Projects Construction Branch, established by the Defence Purchasing Board a few months before the outbreak of war, was taken over when the Department came into being in April, 1940. The

primary function of the branch is to handle the business arrangements of defence construction contracts. In addition, it handled some of the industrial construction work done by or for Munitions and Supply. As the demand for munitions developed, the branch arranged for the construction or enlarging of some manufacturing plants and factories, but most of the plant expansion has been arranged by other branches.

Until the spring of 1940, the value of contracts awarded was comparatively small. After the fall of France, the volume was greatly increased. The construction of schools for the Air Training Plan went forward as fast as the drawings and specifications could be turned out. Military training centres were ordered for completion within six weeks. Aircraft factories were started. Work on munitions plants commenced.

After the initial rush, the volume of new contracts declined in the winter of 1941, and increased only slightly during the following spring. But when Japan struck in the Pacific, construction projects climbed rapidly to an all-time high. Defence works were rushed to completion on the Atlantic and Pacific coasts. New training schools for the Air Force and the Navy were erected.

In the winter of 1942-43 the volume of new work dropped back to about the same rate as the previous year, and continued at that level until the fall of last year. During the last few months of 1943, construction projects were being undertaken at a rate of approximately $100 million annually.

Comparatively few new projects were being handled at the end of 1943 for Munitions and Supply. Extensions to existing facilities are required from time to time, but fewer such extensions are being ordered. Preliminary information indicates that the 1944 program of the Defence Projects Construction Branch will be lower than in 1943.

At the peak of wartime construction activity, hundreds of engineers, architects and draughtsmen

were employed on defence projects. Works and buildings for the Department of National Defence were mostly designed by the engineering staffs of the Army, Navy and Air Force. Factories, and plant extensions, were designed by company staffs or by architects and consulting engineers as in the ordinary course of business.

The plans thus drafted have covered a wide range, both in size and type of construction. They include docks and wharves, hundreds of barracks and military establishments of all kinds, hangars, aerodromes, factory buildings, storage warehouses; plants for loading, storing, and testing explosives; plants for testing and repairing airplane engines; brass foundries, a tidal dry dock, a shipyard, roads, water works, sewage systems, fire protection facilities, electric distribution systems, and recently factories for the manufacture of penicillin.

In addition, the Defence Projects Construction Branch has supervised the work done by private firms through capital assistance. It has ensured that the structural design is safe and economical, and that the scope of the work is in accordance with the wartime needs of the Department, rather than the post-war requirements of the company.

To check contractual arrangements, five inspecting engineers were appointed to take charge of branch offices in Halifax, Montreal, Hamilton, Winnipeg, and Vancouver. These engineers set up subsidiary offices on major construction jobs, and employed assistant engineers, and time and material checkers, when necessary.

To the end of 1943, the program of the Defence Projects Construction Branch covered more than 4,800 projects. Of the $451 million these projects will cost, $393.7 million will be spent on behalf of the Department of National Defence.

Construction work for the British Commonwealth Air Training Plan and the Royal Canadian Air Force comprised 2,703 projects costing $243,470,626. The

branch handled 894 militia projects, involving an expenditure of $86,276,981. These included coast defence batteries, arsenals, magazines, military camp buildings, storehouses and temporary accommodations. More than 430 naval projects, the total expenditure for which was $60,197,879, included anti-submarine booms, torpedo nets, blocking of channels, barrack buildings, boat houses, storehouses and magazines. The remaining $61 million was spent on behalf of the Department for aircraft and other war plants, ship repair facilities, and arsenals.

Wartime Housing Limited

Since September, 1939, the question of providing munition workers with suitable housing has commanded an important position on the nation's agenda of war problems.

During the first year of war, city and town councils managed to cope with increasing populations. Then, early in 1941, the demands for housing facilities throughout the country reached serious proportions. The flow of labor to production centres had begun in earnest.

By February 24, 1941, the Department of Munitions and Supply had decided upon definite measures to relieve congested areas of housing pressure. Wartime Housing Limited, a Crown company, was created by order-in-council and charged with the duty of finding accommodation for war workers and their families in areas where the need for government action was apparent.

Where possible, the company obtained lands from the municipality, always with a view to getting improved property where possible. Where a property was improved, it was borrowed for the duration of the war; where it was not improved, new town sites had to be constructed. In this way, entire new communities were set up by the company to accommodate plants located in remote areas.

Today cities like Windsor, Hamilton and Halifax have profited by the operations of Wartime Housing to the extent of more than 1,000 new homes each; in

the case of Windsor the number is 2,050. Throughout Canada, more than 17,300 houses have been built, in addition to 69 staff houses, 15 bunk houses, 19 dining halls, 13 hostels, 30 schools, and 48 special buildings. Nearly 100,000 men, women and children are accommodated by this plan, which has already necessitated an expenditure of more than $60 million.

Three types of houses are constructed by Wartime Housing Limited, two containing two bedrooms, and the third type containing four bedrooms. Monthly rental rates are fairly consistent throughout the country, $22, $25, and $30 for the respective units. The Crown company enjoys a monthly revenue from rents today of approximately $625,000.

With the exception of Manitoba and Prince Edward Island, every province in Canada has Wartime Housing units. Riding Mountain Camp which was built for prisoners of war is located in Manitoba. Nova Scotia has a total of 2,256 houses; New Brunswick, 350; Quebec, 2,757; Ontario, 9,598, Saskatchewan, 50; Alberta, 350, and British Columbia, 2,006 houses.

Wartime Housing also administers 350 houses at Sorel, Quebec, 100 of which were constructed under the National Housing Act, and 100 constructed by Sorel Industries Limited.

To initiate a housing project in its particular community, a war industry might bring the need for governmental action to the attention of Wartime Housing Limited directly. Often, however, the Department of Munitions and Supply itself, or the local municipal authority will refer the problem to the Crown company.

When a request for housing is received, Wartime Housing sends its trained surveyors to the locality in question. While many communities are found seriously in need of housing relief, not all can be given consideration under the Wartime Housing Act.

Officials of Wartime Housing Limited regard their problem as that of "manning war plants" rather than of providing houses regardless of the industrial importance

of any particular community. Only those communities serving war industries and requiring homes for actual war workers may be served by the Crown company.

As a result, approximately 50 per cent of the towns and cities surveyed have benefitted from the operations of the company. The rest could not be judged "essential," even though the need for housing, in some cases, was recognized.

Surveys have been made by Wartime Housing Limited in every province. Indeed, many localities have been under continuous observation lest a change in conditions necessitate company action. Some towns have been surveyed several times.

All recommendations for assistance are submitted by Wartime Housing Limited to the Housing Co-ordination Committee in Ottawa. This committee comprises representatives from the Departments of Labor, Finance, and Munitions and Supply.

Once this committee approves a particular project, the company immediately sets out to obtain proper sites, materials, and facilities for sewerage, water, and electric power. The proximity of building lots to war plants is a vital factor in determining sites.

First the company looks for land owned by either the federal, provincial, or municipal governments. If such land is available, it is borrowed for the duration of the war. To secure some salvage value on these lots at some later date, the company obtains a deed to the property before investing money in its improvement.

When private property is purchased, efforts are made to obtain such land at a fair price. If, however, an early agreement with the owner cannot be reached, the land is expropriated and the details of legal settlement are handled for the company by the right-of-ways department of the Canadian National Railways.

The architectural division of Wartime Housing makes certain that all construction plans satisfy the tastes of the various communities in which projects are initiated.

Basic principles of modern town planning, however, are carefully followed. Once the contract is awarded to a successful tenderer and a schedule of completion dates agreed upon, the purchasing and priority divisions of the company begin to assemble heating stoves, blinds, screens, storm windows, cooking stoves and other equipment so that each house can be occupied immediately on completion.

Where staff houses are built, the problem for the company becomes more complicated. Not only must these buildings be completely equipped for living, dining, and recreational activities, but they must be properly administered by the company. The serving of meals for 1,000 persons at one sitting is an example of the variety of duties the company discharges in the course of its over-all operation.

So complex are the problems of national housing, that in some instances, the company has to provide facilities usually taken for granted. As a result, garbage collection, police protection, mail delivery, street lighting and even telephone services often become charges upon the company.

To provide its housing colonies with municipal benefits, Wartime Housing Limited enters into careful negotiations with town councils and school boards. Today, all provincial governments have validated the company's policy of paying to the various municipalities, in lieu of taxes, $24 per annum for a two-bedroom house and $30 per annum for a four-bedroom house. In return, the company expects that its tenants will enjoy the same benefits as ordinary ratepayers.

Wartime Housing Limited has built temporary buildings and loaned them to local school authorities in areas where accommodation for the children of the housing colonies was inadequate. The municipal school boards are then asked to equip, maintain and operate these buildings on behalf of the general community.

Each Wartime Housing community is represented by a committee of three or four of its citizens. This

committee acts on its own initiative in building communal goodwill and spirit. Under this committee is a salaried administrator entrusted with the collection of rents and with the general management of the project. His duties also include the allocation of the houses in co-operation with officials of the war industries concerned.

To prevent fire, the company has followed a strict prevention program throughout its projects. The prime endeavor, of course, is to prevent the loss of life, although the safeguarding of property is highly stressed. Active fire marshals employed by the company conduct educational campaigns, inspect buildings, organize the tenants into firefighting brigades, first aid groups, and evacuation squads. Drills are held at least every two weeks with proper fire protection facilities.

To achieve a collective responsibility amongst its tenants for the welfare of their communities, the company established a tenants relations division. This division concerns itself with a variety of social problems. The supervision of younger children while their parents are busy at the war plants was one of the first to be tackled and solved. Today, playgrounds, nursery facilities, and young boys' and girls' clubs have been organized in many of the settlements. Juvenile delinquency has become a negligible concern as a result of this policy.

Symbolizing the co-operative nature of the Wartime Housing enterprise in Canada, is the monthly publication issued by the company for its tenants. This magazine applauds those with outstanding gardens, suggests methods of beautifying the home, recommends recipes for cooking, reports on the activities of the company, and promotes the various enterprises of each community.

Today, Wartime Housing Limited has completed the first and most important phase of its work, the construction of homes for workers who left their normal places of residence to lend a hand in war industry. Now that Canadian war industry is levelling off, Wartime Housing Limited is turning from new projects to an even more

careful concentration on the social administration of its already established communities. The head office of the company is in Toronto.

Construction Control

By 1941, the rapid expansion of industry had taxed the nation's resources to such an extent that Canada was forced to limit construction of new buildings to those essential for war or civilian requirements. A Construction Controller was appointed, whose task it is to decide what construction work may be undertaken during the war.

One of the first acts of the Control was to put a ban on new construction costing over $10,000, and on repairs or alterations amounting to more than $2,500. The Control also ruled that no equipment or machinery costing more than $5,000 could be installed in plants or buildings except under licence. This order, however, did not apply to the farming, mining, logging, commercial fishing, or transportation industries, or Dominion Government projects, and the building of dwellings also was permitted.

At the same time, close liaison was set up with other controls and branches of the government. Because of the shortage of power in certain areas, the Power Control was consulted in all cases where additional power was required. Similar co-operation existed with the Oil, Steel, Timber, and Metals Controls.

By the end of 1941, acute shortages of metals and other critical materials were developing, and by the beginning of 1942, the restrictions over these materials were stiffened. Consequently, broadened powers gave the Control jurisdiction over all construction, repair, remodelling, and installation projects excepting only those owned or financed by the Dominion government. Included in these powers was control over the installation of machinery and equipment.

In order to deal with problems arising throughout the country, regional committees were set up. Two advisory committees were appointed, one in British

Columbia, the other in Manitoba. Representatives of the Wheat Pool, the North West Line Elevators, and other grain companies, were members of the committee in Winnipeg. Later advisory committees also were appointed for Ontario, and for Quebec and eastern Canada.

By the fall of 1942, the Construction Control had virtually eliminated all non-essential building projects and had restricted the use of building materials containing steel, copper, zinc, and rubber.

Still in effect at the end of 1943, but likely to be revised in 1944, this order placed the following restrictions on the cost of various types of construction which could be undertaken without a licence from the Control:

Plant construction, repairs, additions, or alterations	$2,500
Installation of equipment in plants	2,500
Where any building included in a plant project is to be used in whole or in part as a dwelling place, limit for such building	500
Construction, repairs, additions, or alterations, or installations of equipment for buildings other than plants (including dwellings)	500
Grain elevators or grain storage warehouses in area west of Port Arthur and Fort William and east of the Rockies, construction or repairs	1
Installation of equipment in grain elevators or grain storage warehouses in Prairie area (as defined above)	500
Construction, repairs, or alterations for grain elevators or grain storage warehouses in all other areas of Canada	2,500
Installation of equipment for grain elevators or grain storage warehouses in all other areas of Canada	2,500
Conversion of gas or oil burning equipment to use of other fuels	500

Problems in connection with the expansion of food production arose, but were solved in co-operation with the Department of Agriculture.

The addition of lumber to the growing list of building materials in short supply soon necessitated a further tightening of restrictions. Early in 1943 the Timber Control issued an order which provided that no person shall buy more than $1,000 worth of lumber and millwork for construction or repairs at any plant, or more than $200 worth for construction or repairs of a building other than a plant, unless a permit has been obtained from the Timber Control, or unless the cost of the project is such that it requires a Construction Control

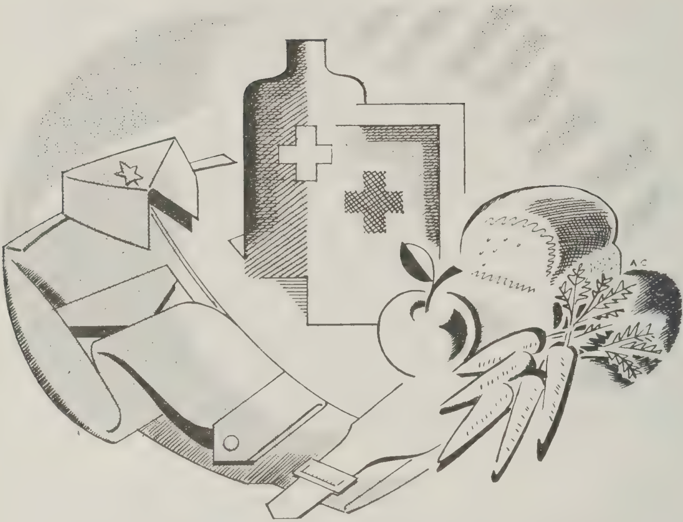
licence and such licence has been obtained. The order allowed for certain exemptions to those requiring permits.

In the early months of last year, it became evident that more and more cities and towns were suffering from a serious housing shortage. Licences were granted for ordinary small homes. If public utility services were not available on the immediate street frontages, an extra amount was permitted. However, in line with his announced intention of discouraging all building activities other than the erection of inexpensive housing accommodation in crowded areas, and construction essential to the war program, the Controller made it a policy to refuse licences to those who might wish to build theatres, clubs, museums, galleries, and many other civilian structures.

Apartment house construction was confined to six- and eight-family dwellings, where that type of housing provided the cheapest form of accommodation. Further, the Control permitted the erection of such buildings as schools, temporary churches or church basements, or administrative buildings only in areas where such buildings were necessary to provide for concentrations of the armed forces or war workers.

Through the licensing operations, the Control has postponed a large number of projects, which will undoubtedly be undertaken as soon as restrictions are relaxed and materials and labor become available. Thus, a backlog of post-war activity is being built up.

While much of the work which has been postponed does not show on the records of the Control, it is estimated that construction projects deferred amount to more than $310 million. As the average of the construction industry in the last ten years was approximately $20 million a month, the backlog will amount to more than a normal year's operations of the industry. These figures do not take into account federal and provincial projects which have accumulated during the war years.



GENERAL PURCHASES

THE nimble fingers of 2,000 men and women in a Toronto factory complete more than 2,000 battle-dress uniforms daily.

A Saskatchewan poultry farmer rises well before dawn every day to ship ten crates of eggs to an army training centre.

Continuous operation, 24 hours a day, seven days a week, will enable a Montreal plant to finish on schedule an order for enough copper wire to girdle the equator more than seven times.

The workers in a British Columbia sawmill take pride in having produced in 1943 almost twice as much lumber as in the previous year.

A ribbon of gauze was fed continuously through a rolling machine in an Ontario factory for five months to fill an urgent order for special bandages.

These are fragments from the far-reaching activities of the General Purchasing Branch, the oldest and one of the most important branches of the Department of Munitions and Supply. They are mere sidelights arising from the awarding of more than 700,000 separate contracts, the spending of more than three billion dollars, since the war began.

From a whaling station on the remotest shore of British Columbia to the depths of a coal mine stretching far out beneath the sea on the Nova Scotian coast, Canadians labor to produce a huge range of articles and materials without which the best armed forces in existence might be rendered impotent within a matter of days.

The General Purchasing Branch, comprising 13 divisions, is responsible for almost everything required by the forces, other than actual weapons of destruction or defence. It buys a vast assortment of goods in astronomical volume, running the gamut from salt to steam engines, from tea to trip hammers, from pins to pine trees.

To achieve the volume required and to obtain the highly specialized items needed not only by our own armed forces, but by our Allies, the General Purchasing Branch has utilized to the full the resources of thousands of Canadian factories, large and small, and has brought about a great expansion of productive facilities. The true measure of this purchasing program will be reflected in the post-war period.

First Purchasing Agencies

General Purchasing is the veteran among the many branches of the Department of Munitions and Supply. It came into being on July 14, 1939, as the Defence Purchasing Board and functioned as such until November 1, 1939, when it became the War Supply Board. It was made a branch of the Department when the latter was formed on April 9, 1940.

The initial mobilization of the armed forces created an urgent need for uniforms and personal equipment for the thousands of men who thronged to the colors. This was the first task of the newly created purchasing branch.

War had come so suddenly and unexpectedly that no adequate sources existed. Few textile manufacturers were ready to promise immediate deliveries of great quantities of serge for uniforms and greatcoats, and those who could undertake rush production had had little or no experience in making army cloths. Nevertheless, orders were placed and production begun, but for the first few months the results were far from satisfactory. Khaki was delivered to the garment factories in as many as ten shades, and there was a marked variation in quality. Time and experience remedied the situation, however, and by December, 1939, deliveries of battledress had climbed to 1,000 uniforms daily. The output increased steadily until the peak was reached in 1943, when Canadian factories were able to turn out up to 55,000 battledress and 20,000 greatcoats a week.

Uniforms and greatcoats were merely the beginning. Winter was coming on when the First Division was being readied for departure, and underwear was a necessity. Three or four knitting mills went into all-out production and the First Division left on time with enough knit goods to go around, and to spare.

Purchasing agents scoured the country for socks, shirts, caps, cutlery, cooking utensils, shaving kits, medical supplies, garbage cans, and possibly 10,000 other items. Pressed by the swiftly approaching sailing date for the First Division, harassed by equally worried military men, at their wits' end to discover sources and to speed deliveries, the staff of General Purchasing bent every effort to meet the stream of requisitions which poured in from Defence headquarters. Orders were placed by long distance telephone and telegraph because every second counted. Supplies were snatched up from factories, wholesalers, even retailers. Manufacturers were spurred and encouraged into fast action. Thousands of boxes and packages were sped to Halifax by express, some by airplane, and when the First Division convoy set sail one frosty dawn late in 1939, virtually every item of urgently needed equipment went along with the troops.

A half-dozen men and three or four girls bore the burden in those hectic months immediately following the outbreak of war, and even when the branch moved in December, 1939, into more spacious offices in Ottawa's first wartime temporary building, the staff had increased to only 35 persons. The nucleus of the purchasing organization was well established, but its troubles were not over. Every new requisition brought a new problem. Every increase in demands created a new puzzle. The officers of the branch began to specialize and divisions were created so that each field of purchasing might be in the hands of men thoroughly familiar with its characteristics.

Clothing and Textiles

The need of the armed forces for clothing predominated for many months. By midwinter of 1939-40, deliveries of battledress, greatcoats, and other essentials were beginning to flow smoothly, and the Purchasing Branch began to look ahead. Every effort was made to forecast the needs of the forces and to prepare for them, but it was well into 1940 before the military authorities decided definitely upon the type of summer dress to be issued to the men. The delay placed terrific pressure upon the manufacturers and it was necessary for the Department to assign men in the field to iron out kinks in production and to expedite deliveries.

The capitulation of France in June, 1940, brought added complications. Canadian military requirements were doubled almost overnight. Requisitions were received for 25,000 battledress and 20,000 greatcoats a week to equip 160,000 men. By September, most factories had attained the required schedules. The blanket mills were rolling at top capacity. The output of underwear had mounted to 30,000 units weekly. Shoe firms were delivering 30,000 to 35,000 pairs of boots each week.

The Commonwealth Air Training Plan began to get into full stride early in 1941, with consequent heavy requests for many articles which had not been purchased previously, such as flying suits, gloves, special boots.

First purchases were made, also, of uniforms for internees and prisoners of war, and clothing was needed for war refugees. The clothing for internees and prisoners was made in strict accordance with the regulations laid down by the Geneva Conference. Both summer and winter garments were distinctive because of a large red circle sewn into the back of the jacket, and a three-inch red stripe on the trousers.

The branch was given some intimation late in 1941 that the Army would require a walking-out uniform for off-duty wear, but the actual requisitions were not received until the following spring. Again it was necessary to assign field men to aid manufacturers in getting production underway and in maintaining the flow of deliveries. The Army also asked for such accessories as shoes, neckties, dress socks, and shirts, all of which had to be obtained quickly as summer was approaching and the men had been advised that walking-out uniforms would be issued.

The need for uniforms and equipment for the women's divisions of the services developed in the autumn of 1941, and the branch had to seek new sources. Many difficulties were encountered, particularly in stockings, and the services had to be satisfied for the time being with hosiery of any type available in any shade of khaki.

The closing months of 1941, and the early part of 1942, saw huge increases in clothing needs of the Air Force and Navy, because of heavy enlistments and expansion, but manufacturers co-operated to meet the situation and adequate stocks were built up and maintained.

The volume and variety of the business handled reached such proportions by the spring of 1942 that it was considered advisable to split the Clothing Division into two units, one to look after uniforms and textiles, the other to purchase clothing and anti-gas equipment.

The seizure of Far Eastern rubber sources by the Japanese compelled the services to accept raincoats and rubberized fabrics made from substitutes. A series of experiments was conducted and every known substitute was tested. Finally, orders were given for 1.2 million

yards of Army raincoating, and 800,000 yards of Air Force raincoating, made from a base cloth of ordinary cotton coated with a synthetic known as vinylite. The companies which had made rubber raincoatings could not handle the substitute materials, and new sources had to be developed.

In the early fall of 1942 word was received that Great Britain would need one million suits of battledress and 500,000 greatcoats. A survey was made and manufacturers agreed to take on this huge order in addition to their existing contracts for Canadian requirements. At that time output was being maintained at 15,000 battledress and 10,000 greatcoats weekly, but this was boosted to 55,000 suits and 20,000 greatcoats through the fall and winter months. Orders also were received for large numbers of lined and unlined parkas, winter guard suits, marine garments, kersey shirts, and other winter equipment for the forces. Requisitions came through for 650,000 sets of web equipment for the Canadian and other empire troops, and Great Britain asked for six million pieces of knit goods. Production in all lines jumped to new levels. The peak was reached in the spring of 1943 when 100,000 pairs of footwear of all types were produced each week.

The shortage of rubber created many problems. Requisitions for a large number of ground sheets were held up pending the completion of tests with synthetic and reclaim rubber, and finally a fabric treated with reclaim proved satisfactory.

The Textiles Division did not come into being until April, 1943, when the Clothing Division was divided. The complexity of its work is indicated by the fact that in 1941 only 18 types of textiles were needed to meet all needs of the forces, as compared to 49 in 1942 and 110 in 1943. Of 21 mills producing the standard drab serge for battledress, two only are equipped to perform all operations from the raw wool to the finished cloth.

In 1939 the needs of the armed forces took about eight million pounds of cotton, approximately five per cent of the total output of Canadian mills. In 1940 the

requirements jumped to 24 per cent (37.3 million pounds); 1941 to 31 per cent (65.1 million); 1942 to 43 per cent (91.2 million) and in 1943 to an estimated 47 per cent (99.5 million). At the end of 1943 more than 300 million pounds of cotton had been used in meeting the needs of the armed forces, and an additional 11.6 million had been imported for special purposes.

The consumption of woollens from September 1, 1939, to December 31, 1943, amounted to 42,240,932 yards of cloth and 4,287,798 blankets.

The shoe manufacturers of the Dominion turned out almost 3.5 million pairs of military footwear of all types in 1943, as compared to 2.9 million pairs in 1942. The production peak was reached in April, 1943, when the manufacturers produced about 85,000 pairs a week, under Munitions and Supply contracts.

When the war broke out each of the services had but one type of standard footwear, but today many types are being made to meet such special needs as those of parachute troops, motorcyclists, tank crews, and women's divisions. Ten manufacturers were lined up for the initial production program and delivered up to 5,000 pairs per week for the three services by the end of October, 1939. Production increased to 10,000 pairs weekly by the end of 1940, 15,000 pairs weekly by December, 1941. The services stepped up their requirements in 1942 to such an extent that the number of manufacturers was increased from 10 to 31, and the weekly production from 15,000 to 42,000 pairs.

Long-range planning, some alteration of specifications, and a constant searching for suitable substitutes made it possible to maintain the volume of production in spite of material shortages. For example, a malleable iron plate had been used on all military boots until the early part of 1942. After much experimentation, in which the National Research Council gave invaluable assistance, a steel plate was developed which had a wearing quality seven times that of malleable iron.

Barrack Stores

A division of the General Purchasing Branch is responsible for buying all such items as beds, mattresses,

pillows, office furniture, kitchen equipment and utensils, crockery, brooms, brushes, soaps and waxes, typewriters, and a huge variety of other goods required by the armed forces under the general heading of "barrack stores." As an indication of the volume of such purchasing, the value of beds and bedding obtained to date exceeds $6.5 million.

Shortages of raw materials have been a severe complication and have led to constant consultation between the military authorities, the Purchasing Branch, and manufacturers. As a result, many familiar items in which aluminum, nickel, and tin were used before the war now are being made from substitutes that are proving highly efficient and economical. Steel serving trays, for example, have been replaced by plastic trays that are lighter, easier to keep clean, and eminently satisfactory in every way.

Many items of kitchenware supplied to the services are made from enamelled iron and the wear and tear of constant use in military kitchens resulted in a heavy demand for replacements. Departmental officials worked out an arrangement by which chipped and unserviceable utensils are returned to the factory for re-enamelling and go back to the kitchens as good as new. An important saving has resulted, both in money and in materials.

Prior to the war all crockery for service messes was imported from Great Britain, and the dishes used in an officers' mess bore a distinctive crest. At the request of the Department the use of crests was abandoned, and crockery was standardized for all three branches of the forces. This tableware now is being made in tremendous volume by a Canadian company, in excellent quality and at a moderate cost. In view of the heavy demands upon this one company, and also because of the heavy loss through breakage, consideration is being given to the use of plastic cups, saucers, and plates now being given a trial by the services.

If the brush salesman does not call as often as he once did, the answer lies in the fact that requirements of the services and of industry demand virtually the entire

production of Canadian brush manufacturers. One step to facilitate production has been the use of Canadian pig bristles instead of Chinese pig bristles in shaving brushes. Paint and varnish brushes now are being made from domestic hair and natural and synthetic fibres instead of from imported bristles.

Commissary Division

When the agents of the Commissary Division go to market to buy food for the fighting men of Canada and some of her Allies, they purchase in quantities that would stagger the imagination of the average housewife. In the first nine months of 1943, for example, the Department bought 78,702,000 pounds of meat, 65,354,000 pounds of vegetables, 13,655,000 pounds of butter, 14,572,000 dozen eggs, 16,687,000 tins of evaporated milk, 62,978,000 pounds of bread, 3,703,000 pounds of tea and coffee, and 93,938,000 pounds of potatoes. The value of purchases for the nine-month period was $67,326,000.

Volume is but one minor problem of the purchasing agents. Much more burdensome has been the task of forecasting requirements and making provision months in advance, so that unexpected shortages will not leave the fighting men without important dietary items.

The War Supply Board, predecessor of the Department, took over the purchase of food from the Department of National Defence in November, 1939. It soon was evident that purchasing could not be handled efficiently and economically from a central headquarters, and branch offices were set up in cities across Canada. Up to September, 1943, purchases by these branch offices had totalled more than $200 million.

Up to the end of 1941, all foods were in plentiful supply and purchases were made on a strictly competitive basis. Since then, the Department's officers have worked in close co-operation with the Wartime Prices and Trade Board, the Department of Agriculture, and other agencies to ensure adequate supplies for the forces. A planned procurement policy has been in effect since late 1941, entailing the building up of reserves of processed foods, and long-range planning.

The needs of the armed forces in such remote areas as Labrador, Newfoundland, and the Northwest Territories necessitated a great expansion of facilities for the dehydration of vegetables and fruits. Apple dehydrating plants were extended and new plants were established in vegetable growing areas. Ample supplies now are available in satisfactory quality at a fixed average price across Canada.

The development and acceptance of Vitamin B flour came into effect in April, 1942, and all bread furnished to the armed forces since then has been of Vitamin B quality.

The addition of grapefruit juice to the standard scale of army rations created not only a purchasing problem, necessitating direct negotiation with United States packers, but an unexpected reaction from the troops. It was found that large numbers of men in the ranks, particularly in the Province of Quebec, had no acquired taste for grapefruit juice and steadfastly refused to drink it. As the juice was an important factor in the army diet, because of its high content of Vitamin C, a substitute was sought. Canadian apple juice, fortified by the addition of Vitamin C in the form of ascorbic acid, met the situation and orders were given for no less than 200,000 cases. Apple juice now is a favorite with troops who would not touch grapefruit juice.

"Iron Rations"

In other wars fighting men were familiar with "iron rations," usually hard tack and bully beef. Today the Canadian soldier is issued a Mess Tin Ration Unit and/or an Emergency Ration Unit that is much more palatable, much more compact, and much more sustaining. The Department and manufacturers co-operated with the Quartermaster General's staff in developing rations which constitute sufficient food to maintain a soldier at the peak of fighting condition for 24 hours, with a caloric value of 3,800 units. The emergency ration has a caloric value of about 800 units and is intended as an emergency meal.

Both rations are packed in hermetically sealed containers, water and gas resistant, the mess tin unit in an amorphous waxed cardboard package and the emergency unit in a sealed tin with key opening device. Elaborate tests were made by the army at a New Brunswick camp, when groups of soldiers were kept on Canadian, British, and United States field rations for a fixed period to prove their comparative values. The 26 components of the army ration are required to withstand a temperature variation from 40 degrees below zero to 120 degrees in the shade, and must be packed for maximum keeping qualities. Experiments were carried on for fully three months before every condition could be met, particularly in reducing the components to the small dimensions required.

During 1942 an emergency arose which demanded immediate shipment of 1,200 tons of special food products and subsistence items, some of which had to be processed, specially packed, and ready for shipment in five days. These included tinned butter, sausage, cheese, and pork. Managers of several plants were told of the urgency of the situation and passed on to their employees as much information as they could. The result was that workers in several plants stayed on the job continuously for two days and three nights to turn out the required food products. Railways co-operated in speeding the shipments. Three cars of flour, for example, were loaded at Medicine Hat, Alberta, and delivered to Vancouver, B.C., in 36 hours.

The humble, sturdy pilot biscuit, perhaps better known as hard tack, passed out of the picture in 1942. For decades little change had been made in the recipe, and no improvement in food value or palatability. The Department suggested to the Standing Committee on Nutrition that something be done about it, and the National Research Council tackled the job. The result has been that the pilot biscuit has given way to a more appetizing and nutritious biscuit developed for the Army mess tin ration.

So that consumers may understand why some foods are hard to obtain in the domestic market, it might be

well to report that the Commissary Division set aside from the 1943 crop, for the use of the armed forces, some 450,000 cases of canned tomatoes, 260,000 cases of tomato juice, 300,000 cases of fortified apple juice, 150,000 cases of canned apples, 75,000 cases of diced carrots, 15,000 cases of diced beets, 5,000,000 pounds of cheese, 9,000,000 pounds of jam, and 2,000,000 pounds of marmalade.

Laundry Section

In the early stages of the war, arrangements for laundry and dry cleaning facilities for the armed forces rested with the Commissary Division, but rapidly became such a heavy task that a special Laundry Section was formed. This unit works in close co-operation with the armed services and the industry.

The problem did not become serious until the latter part of 1941, when requirements of the armed forces first began to exceed the laundry and cleaning capacity in some localities. Assignment of work on an organized basis, and with a fair standard price schedule, alleviated the situation for a time, but as 1942 wore on the difficulties increased enormously because of the growth of the forces, expanding needs of hotels, restaurants, hospitals, railways, and industries, and the fact that many women were entering war work and sending their laundry to the commercial plants. Shortage of labor also complicated matters. By the end of 1942 lack of labor was the most serious factor. The Department and the industry have made extensive surveys, applied what remedies they could, but the lack of laundry and cleaning facilities remained a critical problem until the autumn of 1943. At the end of 1943 this situation was somewhat relieved by the introduction into the industry of married women as part-time workers.

Lumber Division

A special division of the Purchasing Branch has supervised the buying of millions of board feet of lumber, millwork, wallboard, and furniture for army camps, internment centres, and Air Force and Naval establishments. These purchases were not extensive until the summer of 1940, when the Department was asked to obtain 10 million board feet of lumber, several thousand

sash, doors, and frames, and other materials required for military construction in Iceland. With only three weeks to fill the orders, the branch called upon the full resources of a number of suppliers and had the needed materials at the dock at Halifax well before the convoy was ready to sail.

At about the same time the Department of National Defence decided to erect hutments to replace tents in several large military camps, and during July and August of 1940 almost 100 million board feet of lumber were purchased. These large shipments, along with the heavy drain because of the expansion of industry, reduced lumber stocks to a low level, with a resultant tendency toward higher prices, but the appointment of a Timber Controller by the Department of Munitions and Supply stabilized the situation. The demand for lumber increased by leaps and bounds throughout the latter part of 1940 and 1941, when military camps were being erected almost overnight in centres across Canada. Requisitions for camps dropped off in 1942 and 1943, but were replaced by requirements for lumber for overseas construction.

A large volume of wood products has been purchased for Empire countries, with emphasis upon spruce and Douglas fir aircraft timber and plywood. One order called for one million light telephone poles for the British Ministry of Supply.

Millions of feet of wallboards and plasterboards have been bought.

Several hundred thousand tables, benches, and chairs have been obtained for the hundreds of military camps and Air Force and naval establishments. At one time messroom tables were purchased with tops of clear white pine or basswood, but a change was made to Douglas fir plywood. When plywood was in short supply, tops were developed which employed lower grades of lumber and composition, and experiments have been made recently with ordinary hardwood flooring. Several important changes have been made, also, in the specifications for benches and chairs to conserve materials. Filing cabinets now are made from fibreboard and composition to save critical steel.

Among the hundreds of items purchased by this division are carpenters' benches and tool chests, packing cases, camouflage frames, handspikes, levers and loading planks, insulating materials, step and extension ladders, oars, paddles and boat hook staves, tent pegs and poles, commercial and aircraft plywood, toboggans, trusses for army drill halls, and wood wool.

A fuller discussion of lumber and wood products is contained in the chapter, "Timber."

Coal Division

Officials of the Coal Division of the General Purchasing Branch were able to report at the end of 1943 that the fuel situation, so far as the armed forces are concerned, was "fairly satisfactory." Anticipating the coal shortage prevalent in 1943 across the Dominion, the Coal Division did some long-range planning a year ago, built up stockpiles, absorbed any free tonnage that became available. The result is that demands of the armed forces had small effect upon domestic supplies during the winter of 1943-44.

There was no shortage of coal when the division came into being in December, 1940, when the volume of purchases amounted to barely $2.5 million annually with dealers clamoring for the business. Today the situation is reversed, and purchases climbed to $13 million in the first eight months of 1943.

Details of the coal situation during the war are given in the chapter, "Solid Fuels and Gas."

Medical and Dental Division

When the Medical and Dental Division was formed early in the war, its main responsibility was the procurement of medical and dental supplies for the Medical and Dental Corps and certain hospital equipment for the Ordnance Corps. The Medical Corps had little or no stock. The Dental Corps, newly formed, started from scratch. Adding to the task of the purchasing agents was the fact that the Medical Corps was being outfitted under British standards, and many of the instruments and supplies were available only in England and were of types not made or used in Canada or the United States.

One of the first large demands was for the full equipment of an Air Force hospital at St. Thomas, Ontario. In early 1940 came requisitions for the special neuro-surgical equipment for No. 1 Neurological Hospital, established in England under the supervision of Doctors Penfield, Cone, and Stewart, of Montreal.

Canada's success in securing early delivery of large quantities of dental supplies on the first demands issued by the Dental Corps enabled it to equip fully the first units sent overseas.

In view of the need for large quantities of blood for transfusion, the Department purchased a blood drying unit (Desivac) for the processing of blood into the dried blood state. This was installed in the University of Toronto and still is the only unit of its kind in Canada. Hundreds of thousands of litres of dried blood have been produced to date.

The introduction of sulphonamide drugs in 1941 added a new field of purchasing. The first tablets cost almost three times as much as the more efficient tablets being purchased today, and several new sulpha combinations have replaced the original formulae.

A new development brought about in Canada because of war needs was the production of typhus vaccine for the first time. The disease is not prevalent in Canada, and there had been little call for the vaccine, but great quantities were needed by Canadian and British forces operating in North African and European theatres. Quantity production and new methods lowered the cost per litre to less than one-third of the original price. An interesting fact is that the vaccine is obtained by a process employing 1,000 hen's eggs a day. Because of the shortage of eggs, the Germans make some of their vaccine from lice, and it would take about 36 million vermin to produce an amount equal to that obtained from 25,000 eggs.

Before the war Canada imported about 90 per cent of her requirements of dental burs, those tiny grinding devices the dentist uses to enlarge and clean cavities in teeth preparatory to filling. When United

Kingdom deliveries were reduced, and United States houses could not fill export orders, the department sought facilities for the production of burs in this country. Bur-making machines come from Switzerland and are custom-built. A contractor managed to obtain several machines which had been used up to about 20 years ago, and which were still in fair condition. He used the old method of hardening the steel before cutting, instead of the American method of hardening after cutting. The old method produces a much harder bur which should increase its life. The manufacturer now is able to produce sufficient burs for a large proportion of Canadian requirements.

After the entry of the United States into the war, the Department encountered extreme difficulty in obtaining microscopes, badly needed by the armed forces. An appeal was made to doctors, universities, and private laboratories for spare or unused microscopes. The number obtained by this means alleviated a serious shortage. The same method was employed successfully to obtain testing cases required in testing the eyes of recruits.

When announcement was made of the highly successful use of the new Stader splint in the United States, the Department's Purchasing Branch moved rapidly to procure a supply for the armed forces of the Dominion. A field representative in Washington interviewed the inventor, Dr. Stader, and visited the Naval Hospital in Philadelphia to obtain all available data on the use of the splints. Arrangements were made for a demonstration to representatives of the armed services in Ottawa. The reaction was highly favorable. Normally with such new developments, months elapse before a decision is reached for the use of the invention, but in this instance the services made requisitions within a matter of days for an initial supply of $60,000 worth of splints.

Gas gangrene is one of the worst infections the medical services must combat in war, especially when troops are operating in heavily populated countries. The United Kingdom required tremendous quantities of the

antitoxin and Canada undertook to supply 150,000 doses. While this amount may not seem large, from 300 to 400 horses are required to produce it over a period of eight to 18 months. It was a simple matter to award a contract, but suitable stables had to be constructed. No great difficulty was encountered in purchasing the horses, but a serious obstacle cropped up when the contractor sought to employ stablemen to look after the animals. With the help of National Selective Service, enough men were obtained to get the project underway, but a manpower shortage was still a handicap at the end of 1943.

Thousands of gallons of disinfectant are required by the armed forces. Supplies must be bought at a time of year when the liquid may be shipped without danger of freezing, otherwise deliveries must be made by express. By confining purchases to a six-month period and building up reserves, a substantial saving is possible.

The layman, gazing with awe upon the average hospital X-ray installation, realizes the extreme delicacy of the equipment. A field X-ray unit purchased for the Canadian Army is so completely protected that it may be dropped from a truck, rolled down a hill, or tossed across a room by a bomb explosion without suffering harm.

Two companies in Canada now manufacture a special folding dental chair developed by the Canadian Dental Corps, so portable that it may be packed with ease in a single trunk.

In the latter part of 1943 the Department completed negotiations for the large-scale manufacture in Canada of the important new drug, penicillin. The requirements for this life-saving drug were described as "astronomical."

The Medical and Dental Division has followed since its inception a policy of obtaining everything possible from Canadian sources. Facilities have been created for the production of scores of items never previously made in the Dominion, among them visual acuity test apparatus, Bishop Harman apparatus, bone drills, X-ray film developing hangers, dental burs, infusion and transfusion

sets, sulphonamide estimation apparatus, gas mask spectacle frames, mobile X-ray units, tangent scales, Mennell apparatus, rotary hexagon lamps, and water testing sets. In the early months of the war, 100 per cent of Canada's requirements of splints came from the United States. Sources have been developed in Canada, and today not more than one per cent of our splints are imported.

Gasoline and Paints

Visualize a train of tank cars so long that the caboose would still be in Montreal when the locomotive entered the outskirts of Toronto, or a fleet of 500 lake tankers drawn up in review, and you have some conception of the volume of purchases of gasoline, fuel oil, and lubricating oil purchased by the Gasoline, Lubricating Oils, Paints and Varnishes Division of the General Purchasing Branch. This year alone the division has contracted for 250 million gallons of naval fuel oil. Since its inception the division has purchased 178 million gallons of gasoline of all kinds, a large proportion of which has been high-octane fuel for aircraft.

Standardization has been an important factor in making possible the purchase of gasoline and oils in the huge quantities needed for war purposes. Four refiners were able to supply the entire requirements in the early stages of the war, but there now are seven suppliers of aviation gasoline in the Dominion.

Lubricating oil for aircraft is produced under very rigid control and inspection. The needs of the Dominion were so small in peacetime that the oils were imported from the United States, but when the volume increased to unprecedented proportions, equipment was installed in Canada to meet the demand. This has meant a saving of many thousands of dollars.

In the early days the purchase of naval fuel oil was complicated by the number of grades and types required. The suggestion was made that one type be standardized for use in the majority of Allied warships. After many tests and consultations, this grade was set up and accepted by all purchasers and suppliers. Large quantities of diesel oil also have been purchased.

Under the heading, "Oil," a chapter in this booklet tells the full story of the oil supply difficulties since the war began.

The buying of paints and varnishes has offered many interesting and unusual problems. In addition to hundreds of thousands of gallons of more or less standard paints for buildings, ships, and other uses, the division has bought special gas detector paints, camouflage paints, finishes for the interior and exterior of shells and bombs, and even special coatings for identification cards. Some paints called for under contract specifications have been extremely difficult to obtain. In the latter part of 1943, for example, the division sought sources for a special finish for the interior of fresh water containers, for naval use, which would be impervious to all kinds of contamination. Total paint purchases since the beginning of the war have exceeded $6 million.

Unusual Purchases

Perhaps no division of the Department has purchased a greater tonnage of war supplies than the Naval and Militia Stores Division of the General Purchasing Branch, because, in addition to "stores," it has supervised the buying of hundreds of millions of dollars worth of aluminum, copper, zinc, lead, antimony, cobalt, chromium, and several other metals mined in Canada, on behalf of the United Kingdom and Empire countries. The volume of metal purchases has run into many hundreds of thousands of tons.

While metal purchasing has been one of the main responsibilities of the division, its chief purpose at the outset was to buy a host of items required by the armed forces. The naval authorities requisitioned miles of chain cable, chain fitting, flotation barrels and buoys, anti-torpedo and anti-submarine nets, gate-opening winches, and wire rope, for harbor defences. All kinds of special equipment was needed for corvettes, minesweepers, and destroyers, such as navigation instruments, electric logs, course indicators, anchors, anchor chain, shackles smoke generators, smoke floats, voice pipe

gear, breathing apparatus, life belts and floats, gasoline and diesel engines, watertight doors, echo sounding equipment, and diving gear.

For the Army the division has bought such things as portable bridging and pontoon equipment, gunnery targets, magazine shelters, gun emplacement equipment and camouflage for coastal defence batteries, reconnaissance boats, folding boats, and target frames. The Air Force has required steel masts for radio antennae, gasoline storage tanks, photographic equipment, and a host of other items.

The greatest difficulty in the early days of the war lay in the fact that the orders required strict adherence to British specifications, and Canadian manufacturers had to adapt their production to unfamiliar methods and materials. In addition, orders were placed for many items never previously made in the Dominion and requiring a high degree of skill and precision. Chain and hand-forged chain fittings were unobtainable at first, and were purchased in the United States, but Canadian sources were developed and this country now is wholly independent of the United States or United Kingdom for harbor defence needs except for very heavy chain cable.

Industries were created in the Dominion to produce for the first time such items as compasses and azimuth circles, electric logs, course indicators, anchors, boiler tubes, and binoculars. The latter had never been made in quantity in North America, but Canada and the United States today supply all their service demands. Even such things as pulley blocks usually were imported from the United States or Europe before the war, Canadian manufacturers having been unable to compete against cheap labor and volume production. Today, however, all Canadian Navy and Army requirements are met by Canadian plants.

Hardware Division

Purchases made by the Machinery, Machine Tools, and Hardware Division have run into many millions of dollars since the unit came into existence in December,

1939. In the early months of the war, particularly, the division had to resort to extreme devices to obtain equipment that was urgently needed by the armed forces. For example, a requisition was received one evening in the autumn of 1939 calling for the installation of a gas-fired kitchen range at a military camp in Ottawa by noon the following day, so that arriving troops might be fed. A departmental official happened to know that a range of this type was being replaced in a Capital City tea room by a coal-fired range which was just being installed. He got in touch with the manufacturer's representative at once and a visit was made to the restaurant. The range was in service and the chef had the following day's allotment of pastry in the oven. Early next morning mechanics disconnected the range, loaded it on a truck, rushed it to the camp, and made the necessary connections. When the troops arrived the range was in operation and the mid-day meal was served on time.

The gas range was but a sample of the variety of items purchased. Plumbing equipment, storage tanks, boilers, gas ranges, heaters, lavatories, and other requirements were ordered for camps and training centres which sprang up across the Dominion. Machine tools valued at several millions of dollars were bought for a Toronto factory. Steam winches were obtained for naval use at Esquimalt. Machinery was purchased for the Quebec Arsenal, hot air furnaces for air training centres, tools for Lindsay Arsenal, galvanized iron for a Montreal barracks. Hundreds of orders were placed in a matter of days and members of the staff worked from early morning until midnight to handle the flood of business. By the end of 1940, purchases had mounted to a total of $13 million.

Some relief was given to the hard-pressed division staff when the purchase of gauges was transferred to a special Gauge Division. The manufacture of war equipment to extreme tolerances requires many thousands of intricate and delicate gauges. Up to the time of the transfer, the purchase of these gauges was entirely in the hands of a woman member of the staff.

Formation of the Tunnelling Companies of the Royal Canadian Engineers in the fall of 1940 brought rush orders for varied and unusual equipment, including diamond drilling apparatus, much of it for use in building tunnels and fortifications in the Rock of Gibraltar.

The division was well organized when the big rush came after the Dunkirk evacuation. Great Britain was being assailed from the air and needed not only defensive equipment, but the means to combat huge fires. Orders were placed with five Canadian rubber companies for seven million feet of 2½-inch fire hose. Realizing the extreme urgency, the companies devoted their entire facilities to the contract and made deliveries in record time. Britain also ordered $100,000 worth of axe handles.

One interesting contract called for a number of complete sawmills, to be shipped to Scotland for the use of the Forestry Corps.

Steel helmets were an early requirement of the Canadian forces, but it was not until metallurgists and specialists spent months in research work that a suitable helmet was designed, requiring the use of a special high-grade steel. The helmets were required to pass severe tests, including resistance to a .303 rifle bullet fired at a range of 12 feet. Hundreds of thousands of helmets have been made since the first trial order was placed.

Purchases for the R.C.A.F. included almost everything in the firefighting catalogue, from crash tenders to asbestos mitts. Original specifications for one piece of firefighting equipment, a five gallon pump tank, called for a tank made from sheet copper. The purchasing division pointed out that galvanized iron was used successfully for brine tanks in refrigerator cars, and suggested use of the cheaper and less critical metal for the pump tanks. Tests were made and the specification was changed, with a resultant saving of at least $250,000, as well as of large quantities of strategic material. A big saving was made, also, when specifications were changed to permit the use of carbon steel, instead of

high-speed steel, in hand screw-cutting tools, drills, and reamers needed by the Air Force.

In November, 1940, the division made its first purchase of skiis, the order calling for delivery of 6,000 pairs within a month. Canadian firms had made skiis for years, but had never been called upon to produce so many in so short a time. Nevertheless, the demands were met on schedule.

Early in 1941 the Air Training Plan began to operate on a big scale, and demands for hand tool equipment reached such volume that Canadian and United States suppliers worked at top capacity to meet requirements. Schools for the training of skilled mechanics for the Army added to the demand for tools. Ever alert for ways to effect savings, the purchasing office learned that heavy replacement of small cast iron vises was necessary because youthful personnel in Air Force training schools over-rated the strength of these fixtures. A Canadian manufacturer was called in and, after consultation with Air Force engineers, designed a vise made entirely from cast steel. Much to the satisfaction of Air Force authorities, the vise proved to be almost indestructible. It is believed to have been the first cast steel vise ever made, and will be of great post-war value to mechanics. The demands for hand tools became so great that United States suppliers fell behind in their deliveries of certain types, and development of a Canadian source became imperative. A Canadian manufacturer was persuaded to enter into the production of high-grade pliers.

Great Britain's "Food for Victory" campaign was reflected in huge orders for agricultural implements of all kinds, and millions of dollars worth of such equipment was shipped from Canadian plants.

In the autumn of 1941 the division entered a new purchasing field when large orders were received for anti-submarine and submarine-detection equipment. From that time until purchasing of this material was transferred to the Munitions Contracts Branch in May, 1943, commitments exceeded $40 million.

The Battle of Britain brought orders for equipment that could be used by householders in extinguishing fires started by incendiary bombs. A single order came through for 2.5 million feet of garden hose for this purpose.

While barbed wire is familiar on thousands of Canadian farms, it had never been made on this continent in the form required by the armed forces for barbed wire entanglements. This is known as "concertina fencing," getting its name from the springy coils in which it is formed. A Canadian wire manufacturer undertook the task of supplying huge quantities and was so successful that the firm has filled not only the requirements of our own forces and of Great Britain, but has been able to export some 40,000 coils to the United States.

A minor, but nevertheless important item developed for the services was a novel oil can. The container holds four ounces of oil and is fitted with a knurled knob to release the flow of oil. This makes it possible for a mechanic to oil an aircraft engine or other machine with one hand, leaving the other free for operation of instruments or to handle tools.

One of the most extraordinary orders called for 32,000 hammers of several types, the largest single purchase of the kind ever made in Canada.

Among major orders placed in 1942 were those for tunnelling equipment, torpedo components, and oxygen generating apparatus. The first entrenching tools purchased during this war were ordered in 1942, and it is interesting to note that the patterns were identical with those used in World War I.

Production of regulation steel helmets ran into many thousands in 1943, and was supplemented by the making of a first order of 4,000 special plastic crash helmets and 10,000 steel crash helmets for motorcyclists.

Early in July an S.O.S. call was received from Great Britain for 2,200 tons of binder twine, urgently needed because unusually fine weather had advanced the harvest time by three weeks. Canadian manufacturers met the

emergency and the supply of twine was on its way within three weeks. The early harvest also accelerated deliveries of Canadian binders and other farm equipment to England.

Mechanical Transport

There was at least one field of war production in which Canada was well prepared when hostilities broke out in September, 1939—the manufacture of motor vehicles. Not only were the major Canadian plants able to convert quickly to the making of special trucks, but plans and designs already were at hand because of extensive experimental work as far back as 1936.

The Mechanical Transport Division of the General Purchasing Branch came into existence late in 1939, charged with responsibility for the purchase not only of automotive equipment, but such electrical requirements as amplifiers and loudspeakers, generating sets, electric cables, facsimile machines, wireless sets, searchlights, revolving airport beacons, projectors, and other devices. Orders were placed almost at once for the mechanical transport required by the First Division, and rubber companies began work on special tires of a secret type for military use. By the end of 1943 approximately 600,000 vehicles and many millions of tires had been produced in Canada. In the early months of the war all military needs were confined to eight types of trucks, ordinary sedans, and a few station wagons. At present there are more than 100 military types.

Total purchases of the division up to the end of October, 1943, exceeded \$1.4 billion, more than \$1 billion of which was on United Kingdom account. More information concerning the production of mechanical transport is contained in the chapter, "Automotive Vehicles."

Electrical and Wireless

Purchases of electrical and wireless equipment in the early months of the war were small, and the business was handled by a division set up to buy coal, wood, gasoline, oil, lubricants and paints, but by early 1940 had grown to such proportions that a special Electrical and Wireless Division was established.

One of the first major orders placed by the division was for large quantities of special, rubber-insulated cable for the degaussing of ships. Many miles of this cable have been used to protect vessels against magnetic mines. Shortly afterwards, orders came from Great Britain for large quantities of equipment for the famous "Asdic" submarine detector, an undertaking requiring the highest degree of skill and accuracy in manufacturing.

When the Canadian Army placed its first order for wireless sets, it was stipulated they be exact duplicates of those used by the British. The number of sets required was comparatively small, and it was a slow and expensive task to make the sets here, in view of the fact Canadian standard parts are not interchangeable with those made in Great Britain. Delays were occasioned while special dies and tools were fabricated, and it was found impossible to obtain the necessary special tubes from British sources. Consequently, these tubes had to be made in this country. The sets proved highly satisfactory, however, and the majority were installed in tanks which were sent to Russia.

The second set requisitioned by the Army also followed British design, but the Army agreed to use Canadian parts and tubes wherever possible. This simplified the manufacturing problem and, while the manufacture was progressing, Canadian engineers were able to suggest improvements which increased with a small gain in power input the output of the set some four or five times. This set proved to be one of the finest field sets in use.

Subsequent orders for wireless equipment ran into such volume that three manufacturers were brought into the program to produce 35,000 tank transmitting, receiving, and intercommunicating sets. Later the division placed contracts for large numbers of a small transmitter-receiver developed in great part by the National Research Council and popularly known as the "walkie-talkie."

Electric power plants, ranging from the small gasoline-driven battery-charging unit to diesel, gasoline, and steam-driven plants up to 250-kilowatt capacity have

been purchased in large numbers. The largest plant bought was a steam turbine unit of 1,000-kilowatt capacity. The equipment is in use to supply power for military camps and air stations in isolated locations, and also as standby equipment for radio stations. Several plants were required to supply the power for the equipment in coastal defence stations. Some of the units were more than 30 feet long and 15 feet high. Shipment was a problem because of the weight and bulk.

Purchases of the division also included power plants for a floating drydock, large numbers of both standard and special electrical transformers, motors and generating sets, and special generators for degaussing of vessels.

Many problems were presented by large orders for "admiralty electrical fittings" for the distribution and control of electric power on shipboard, because the equipment had to be made to withstand corrosion from sea air and water, as well as the shock of shell burst and gunfire. So numerous were the demands that many manufacturing sources had to be developed.

The armed forces have required many refrigerating units, ranging from the ordinary household type to "walk-in" refrigerators for the storage of large quantities of meat, fruits, and dairy products. The equipment has been installed in camps, manning centres, and on ships. Unusual refrigerators bought by the branch included those for mortuaries, and a special one for testing synthetic covering for electric wire.

Cable of every conceivable type has been purchased in great volume. On one occasion the British Admiralty asked Canadian manufacturers to duplicate a kind of cable made up to that time only in English plants, and an expert was sent out from England to assist in solving production problems. This cable, required for harbor defences, was needed in such abnormal lengths that it was loaded directly from the factory to flat cars, and thence to ships, without the usual packing on reels. Experts were assigned to supervise loading of the cable. One length was consigned to Singapore, but by the time

the ship approached that port, Singapore had fallen into the hands of the enemy and the shipment was diverted eventually to Australia.

A single British order called for 16,000 long tons of bare copper wire. The length of wire in this order was about 120,000 miles, enough to encircle the equator almost five times. It cost more than $6 million. A British Navy order required 2.6 million yards of special wire of 237 different types.

The manufacture of military telephone equipment has been a problem, again because of the necessity of following British specifications and designs unfamiliar to Canadian manufacturers. Shortages of materials aggravated the situation.

The division also handled the leasing and installation of teletype circuits required by the Army, Navy, and Air Force for rapid communication. The annual rental charge now averages $700,000.

A special communication system set up in western Canada involved the purchase of huge quantities of material. So far deliveries have taken 1,200 freight cars, 36 of which were filled with glass insulators alone.

Among miscellaneous electrical purchases have been electric lighting installations, many kinds of ventilating fans, motion picture projectors, searchlights, signalling lamps, battery type lamps for tanks, bicycle lamps, 50,000 life-saving lamps, hundreds of thousands of electric batteries, fans, welding equipment, and a variety of appliances.

In the chapter, "Signals and Communications," more information is given with regard to this vital aspect of Canadian war production.

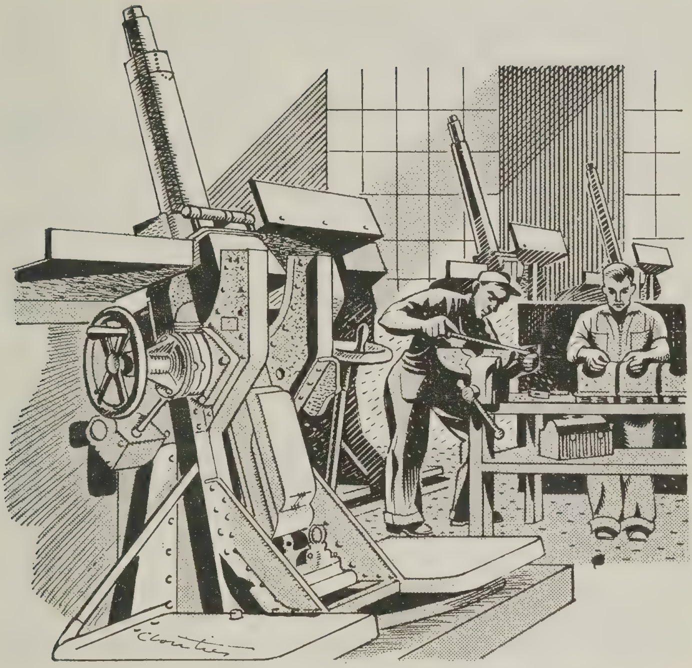
Chemicals and Explosives

Newest of the 13 divisions of the General Purchasing Branch is the Chemicals and Explosives Division, set up in May, 1942, to procure all chemicals, explosives, and pyrotechnics not produced by government-owned projects. The buying of pyrotechnics, in particular,

involves a great deal of experimental work and a constant search for adequate sources of the highly specialized items. The division works in close co-operation with the Chemicals and Explosives Production Branch at all times, and further details of this phase of war production are provided in the chapter dealing with this latter branch.

Included among the items purchased are gunpowder, blasting powder, cordite, trinitrotoluol, dinitrotoluol, new types of demolition explosives, chemicals which produce artificial smoke and fog, signal flares, sea markers, and rockets.

The division has purchased more than 80,000 tons of nitrogen fertilizers for Great Britain and the colonies, and demands are increasing.



GUNS AND SMALL ARMS

"RANGE: 5000 yards. Ten degrees right of zero. Right section: 5100. Left section: 4900. Two rounds. Fire!"

Sitting atop a tree, a Canadian army officer directs the fire of his battery of 25-pounders. At his command, the guns roar, and a German munition dump is blown sky high.

The place is Italy. The guns are labelled "Made in Canada," a label which advertises throughout the world the high quality of the war products turned out by the Dominion, the skill and ingenuity of its workers, the

resourcefulness of Canadian industry and its ability to tackle the manufacture of any piece of war equipment no matter how complex.

Prior to this war, Canada had never even thought of building modern guns. Canadian industrialists and engineers had no conception of the difficulties involved, the complicated design, the innumerable precision parts—there are more than 7,500 on the Bofors, a small gun—the rigid metallurgical requirements, the extreme tolerances in machining and fitting, or the intricacies of the watch-like instruments needed for fire control.

In other words, except for rifles manufactured in limited quantities in World War I, Canadian industry before this war was in the minor leagues, in the field of ordnance production. Not so today, however; the pre-war rookie has become a star performer. From Sydney, Nova Scotia, to Vancouver, British Columbia, scores of gun and gun part plants have been erected. Vast arsenals, working night and day have been making rifles, machine guns, mortars, tank guns, anti-tank guns, field artillery, anti-aircraft ordnance, naval guns and mountings of several types, naval armament equipment, as well as more than 100 types of artillery instruments.

To date, Canadian artillery plants have delivered more than 83,000 separate pieces of ordnance, including 16,000 complete equipments. The total production of guns only is in excess of 22,000. Small arms factories have turned out 983,400 rifles, machine guns and mortars. The dollar value of guns and small arms produced in Canada to the end of 1943 totalled almost $373 million, of which $196 million worth were produced in 1943.

Some 25 major contractors are engaged in the gun production program, and another half dozen on small arms manufacture. These plants employ approximately 50,000, of whom 30 per cent are women, and these figures exclude employees in the ancillary industries, in the shops of the medium and small sub-contractors who supply components for the final assembly factories, and in the many establishments which manufacture fire-control and other instruments and equipment.

The Crown has invested $130 million in the gun and small arms industry. This total covers only plant expansion, machinery and equipment for ordnance production excluding the sums expended for increased facilities in instrument manufacture and for the expansion of ancillary industries.

Early in the war, it was believed that Canada's industrial contribution would be confined to limited quantities of munitions for the United Kingdom. However, with the swift Nazi conquest of western Europe and subsequent serious military setbacks, this country became one of the more important producers of weapons, and not the least of these were guns and small arms.

In the hectic planning days, from June, 1940, to June, 1941, long-range schedules were projected. Guns of certain types, it was believed, were to be manufactured for many years. All plans were formulated on a long-term basis. In some instances, peak output was set to be reached two or three years after the contracts were awarded.

Later, however, the fortunes of war changed—not merely the pattern of warfare, but the whole conflict itself assumed a new shape. A few miles west of Alexandria the Allies turned on the Axis forces, eventually pushed them out of Africa and Sicily, and up the Italian boot. Between El Alamein and the battle for Rome the Allies realized that many changes were needed in the types of armament they were using. The tank was no longer supreme. It was found that by hurling a devastating explosive in the form of a rocket, a large grenade, or a high-velocity shell, the landships could be stopped. Artillery came back, not slow-moving guns, but self-propelled, high-velocity ordnance.

At close range the Bren machine gun and other small calibre automatic arms provided insufficient protection against low-flying aircraft. It was found that the most efficient weapon to ward off the dive-bombers and the strafers was the 20-millimetre gun, used either singly or in pairs.

Thus in the air, on the ground, and also at sea the tactics had changed, and these changes called for revisions in the gun procurement program. The revisions affected Canada as much as other United Nations. Weapons of limited efficiency against tanks, the Boys anti-tank rifle for instance, were abandoned in favor of projectors such as the Piat, which propel rocket-like bombs. On many aircraft, cannon and heavier machine guns replaced the .303-inch machine-guns, and so the production of the .303 aircraft machine gun was discontinued in Canada. Orders for heavy anti-aircraft guns were curtailed. Contracts were let for 20-mm. guns, and for many types of mounts to carry them, for new forms of ammunition and for other new weapons.

But the cancellations or reductions of contracts were not confined to weapons which suddenly became obsolete. Some, indeed, involved guns which probably will be in use until the day the Axis capitulates. Actually, after the fall of France this country was called on to produce large quantities of war supplies, which, had it not been for the constant threat of bombings, might otherwise have been manufactured in Britain. Thus Canadian factories were turning out a substantial share of the supplies necessary to replace the equipment lost by Britain in the Low Countries and in France (roughly the equivalent of a year's output of the United Kingdom), plus enough to equip the great new armies coming into being, plus enough to offset shipping losses from enemy action at sea.

As the war situation changed, so did production. The output of certain arms was reduced before the peak was attained and, towards the middle of 1943, there were large reductions in the production of Army guns.

However, this downward trend was offset to a certain degree by recent contracts awarded for new types of guns and mountings. While the need for Army guns declined, full production of naval ordnance continued at an accelerated pace. Mutual Aid also enabled the government to maintain production in certain plants which otherwise would have become idle. For example, anti-aircraft and anti-tank guns, and small arms, are being made for China.

With more than $100 million worth of new plants and equipment, with war orders on hand totalling several million dollars, with a large share of production commitments under the Mutual Aid plan, Canada remains one of the important cogs in the machinery of Allied gun production. Certainly in proportion to population, its industrial war effort in this field is unexcelled by that of any other country.

The manufacture of ordnance in Canada is subdivided into four main classes: Army guns, naval artillery, fire control instruments and small arms. To this group can be added a separate, but closely related field, the naval armament and equipment field.

A complete gun equipment consists of the gun barrel, breech mechanism, and mounting. The production ratio of such major components varies greatly. Many more barrels are built than the actual number of complete equipments turned out, since barrels have to be replaced after a given number of rounds.

Because the Dominion does not always turn out the complete unit in each type of gun, the Canadian ordnance industry, like the ammunition industry, is highly complex. For instance, the Dominion does not manufacture the Oerlikon anti-aircraft gun, but turns out for this weapon two types of mounts which are more complicated than the gun itself. For some guns, Canada produces merely the barrel; for others, the breech only; for many more, only the mounts.

Army guns comprise weapons of the mobile type, installed mainly on carriages, but also on vehicles, tanks, or self-propelled mounts. Naval ordnance is of a fixed type, the guns being installed on stationary mounts permanently attached to the decks of ships. Small arms comprise the wide variety of portable weapons such as rifles, machine guns, pistols and trench mortars. This class includes most portable weapons which fire unfused ammunition having a calibre of one inch or less, as well as trench mortars.

The production of guns and small arms in Canada covers an exceptionaly wide range of weapons, from the 9-mm. pistol for the Chinese Armies, to such intricate

items as the twin mount for the 4-inch gun, the quadruple mount for the 2-pounder pompom, and the carriage used by both the 4.5-inch field gun, and the 5.5-inch howitzer.

Canada may well feel proud that it is manufacturing several types of standard artillery used by the British Army. With the exception of the heavy calibres for capital vessels, the same obtains for naval guns.

In the following directory of the various guns and small arms made in Canada, no attempt has been made to give a complete description of each type. However, some of the guns are dealt with at greater length, in order to give some indication of the intricacy of artillery manufacture. All types present similar engineering and manufacturing problems which vary according to the complexities of the equipment.

The weapons made in the Dominion during this war are listed in the directory, although contracts for certain types have been completed, while others are scheduled to go into production only during the coming year.

ARMY GUNS

The Bofors 40-mm. Anti-Aircraft Gun. Weight, 5,500 pounds. Length of barrel, 7 feet, 4½ inches. Elevation range, minus 5° to plus 90°. Rate of fire, 120 rounds per minute. Ceiling, 19,000 feet. Weight of projectile, 2 pounds.

This automatic weapon has probably been the most widely used of all anti-aircraft guns employed during the war. It is of Swedish design, but its present carriage is British. The Bofors is manufactured in Hamilton, Ontario, in a government-owned factory operated by an elevator company. It is one of the largest war plants in Canada, covering an area of 7½ acres, and employing at peak in excess of 5,000 workers, a large percentage of whom are women. The cost of plant and equipment totals $14 million. The factory produces the complete gun, including the mobile mounting. The first complete Bofors equipment was turned out at the end of 1941, 16 months from the date of the official go-ahead in August, 1940.

By the beginning of 1942, production was in full swing. The set objective of more than 100 units per month was reached in May, 1942. The output was later stepped up to twice the original objective. Canadian-built Bofors guns have been shipped to all parts of the world, including the United Kingdom, the United States, the Middle East, Australia, New Zealand, and South Africa. Present production of standard Bofors gun-on-carriage is chiefly for China under Mutual Aid.

In addition, Bofors guns are being turned out for installation on a new self-propelled (wheeled) mount in a Canadian version of the British model, embodying several design features and improvements on the British prototype. The Canadian Bofors "auto-mount" has been adopted for production in the United States.

Bofors guns are also being made for installations on single naval mountings. The majority of these are for the British Navy, but a few are earmarked for Fighting French ships. The naval mountings for the naval Bofors are produced in Calgary. All in all, the Bofors plant at Hamilton, has turned out more than 4,000 guns, more than 3,000 complete equipments, and in excess of 25,000 barrels.

The weight of the Bofors barrel, when first forged, is 425 pounds, but machining reduces this to 227 pounds, and brings down the length from 94½ inches to 88½. Upon arrival at the ordnance factory, the forgings are first rough turned, and the first bore is drilled through the full length of the barrel. Second turning and boring are followed by finished turning, boring, honing and rifling, the finish milling, and the fitting of the breech end to receive the breech ring and the gun breech. The average time taken in Canada in the first month of production for machining the Bofors barrel was 167 hours. By September, 1943, this had been reduced to 32 hours.

The 3.7-Inch Anti-Aircraft Gun is probably the largest anti-aircraft gun on wheels. It is the big brother of the Bofors gun, and the intermediate gun between the 40-mm. and the 4.5-inch. A gun of great power

and range, the "three-point-seven" has been one of the Allies' mainstays against enemy aircraft, particularly high-flying bombers. It weighs 7½ tons, has a rate of fire of 18 projectiles per minute, and can hurl its 28-pound shell up to 35,000 feet. The complete equipment is turned out in the Dominion.

No weapon better illustrates the complexities of gun manufacture. The forgings for the barrels are made in a Hamilton steel plant, and the machining in an ordnance factory in the same city. Forgings for the breech mechanisms are fabricated in plants extending from Nova Scotia to Ontario. The mobile mounting, which has no less than 1,200 different parts, is manufactured in a huge government-owned plant at Peterborough. Finally, the amazingly intricate electrical firing control and optical equipment is manufactured in other Canadian cities.

The barrel forging weighs 2,500 pounds when it reaches the gun factory. It is machine-turned and bored for auto-frettage, the hydraulic process which subjects the barrel to internal pressure to leave the inner layers in a state of compression. After the auto-frettage comes the low temperature treatment to restore elastic properties, the outside finish machining, boring, rifling, chambering, and other operations, 32 in all. It formerly required 465 hours to reduce the 2,500-pound forging to 1,300 pounds. At peak operations, this time had been cut by 70 per cent.

The breech ring, which weighs about as much as the barrel, also requires a lot of complicated machine work, and takes several weeks to complete.

The gun proper is turned out in a government-owned ordnance plant in Hamilton. This factory cost close to $10 million, and at peak employed 1,000 workers. The final assembly of the complete equipment is carried out in the Crown plant at Peterborough, which employed at peak some 2,000 workers. The latter plant cost nearly $12 million. Prior to manufacturing the 3.7-inch carriage, this factory was turning out the smaller mobile mounting for the 2-pounder anti-tank gun.

Scores of Canadian 3.7-inch guns have been shipped to destinations the world over, including Turkey and Iraq. The original contract called for the manufacture of 20 guns per month. This was later increased by more than five times. Output of spare barrels was expanded accordingly. More than 1,500 complete 3.7-inch equipments have been built and more than 3,000 additional spare barrels turned out.

Illustrative of the tremendous savings effected in the gun and small arms industry as a whole is the fact that the cost of the 3.7-inch barrel forging has been reduced from $1,650 to $850 and the machining, from $1,733 to $290.

Anti-Aircraft Gun Barrels. In addition to its production of complete equipments, the Hamilton 3.7-inch gun plant has turned out 2,500 barrels for another type of anti-aircraft gun of a calibre slightly smaller than the 3.7-inch, as well as a small quantity of barrels for the British 4.5-inch anti-aircraft guns. Both types were produced on existing 3.7-inch machinery.

The 25-Pounder Field Gun. This weapon covered itself with glory as Montgomery's mainstay during the race across the North African desert. Canadian troops in Italy are using it widely and have acclaimed it their favorite weapon. It is the most popular of all British field guns.

Twenty-five pounders can lay down a rapid concentration of shell fire. In Italy, one gun fired 16 rounds in 55 seconds, something of a record when it is remembered that each shell has to be fed individually to the gun. On the heaviest day during the battle of the Moro River which culminated in the capture of Ortona, the 25-pounders pumped 250,000 rounds, or 3,125 tons of shell, ahead of the advancing infantry. During that day, the guns fired 600 rounds apiece.

The idea of producing cannons in Canada first dawned on a French Canadian industrialist of Sorel, Quebec, long before the war, and thus many months before the fall of France this country had already started to develop

production facilities. The industrialist went to London, and secured an educational order for 100 25-pounder guns, and 200 carriages. The contract was signed July 19, 1939; and it was agreed that the firm would expend $5 million as capital, and the British War Office $500,000.

Owing to the lack of ordnance engineers in Canada, the company had to make arrangements with the French Schneider works, famed gun makers, to secure a complete staff to handle all the technical aspects of production.

After war broke out, 25-pounder equipments were required in larger quantities, and the government developed the project with the Sorel interests. Eventually, the amount invested by the Crown in this great project totalled $12 million. Production was scheduled to run at 25 units a month, and this was increased to 75 a month, although after production began, it was found that the plant capacity was more than 100 equipments per month.

In the early days of the development, problems galore were encountered. The equipment was made to British design, and subject to British inspection, but under the supervision of French technicians accustomed to continental practice. The language difficulties were enormous. The French Canadians who administered the project had to solve the differences of opinion between British inspectors and French experts. One of their problems was the difficulty of understanding in technical terms the Frenchmen's French, or the Englishmen's English.

Complete absence of skilled help in this quiet, rural area of Quebec Province, where the plant was built, was another major worry, but it was finally solved by a large housing project which made it possible to bring skilled workers from other districts, and by an apprentice school which turned out hundreds of workers trained for specialized jobs.

After the fall of France, the French technicians. worried over the plight of their families at home, departed one after the other. A control committee was

formed to represent the interests of the British and Canadian governments, and of the firm. Technical supervision and expert plant management had to be secured in a hurry. An automotive company was called upon to provide the necessary staff. The required technical and production men were loaned, went to work at once, and the undertaking was saved.

The Sorel gun plant is probably the only artillery manufacturing centre in the Western Hemisphere where a complete gun is made, that is to say where the steel, forgings, heat-treatment, and machining are all done in the same plant. Spreading over 600,000 square feet, the plant employs 3,000 workers.

The 25-pounder gun was designed to replace the old 18-pounder equipment. It is the chief weapon of field artillery units. With its standard carriage it comprises 1,286 parts. The gun barrel consists of two tubes, the inner one being replaceable. The breech mechanism is of the sliding block type which facilitates loading and extraction. It is a quick-firing gun. The continual shocks and strains of rapid fire demand precision work of the highest degree, particularly in the breech mechanism, sights and recuperator systems.

The Sorel artillery factory has turned out more than 1,500 standard 25-pounder equipments on standard carriages, and in excess of 500 other guns for special purposes. The original cost of $21,000 for the 25-pounder gun and carriage has been reduced to $9,000.

The 25-Pounder Trailer. More than 6,000 special trailers for 25-pounder guns have been turned out in Canada, the majority by an agricultural implement factory in Smiths Falls, Ontario, and the remainder by a road machinery company in Saskatoon, Saskatchewan. These sturdy steel ammunition carriers, mounted on tires, carry 16 trays. The trailer is attached between the artillery tractor and the gun itself. The manufacture of this equipment in Canada has been discontinued. The average cost of each unit has been in the neighborhood of $750.

The 2-Pounder Anti-Tank Gun. This little gun which proved to be inadequate against the heavier types of tanks, was produced in large volume in Canada before its manufacturers were ordered to switch to the production of the heavier 6-pounder. Some 400 were produced as straight anti-tank guns mounted on mobile carriages, while 100 were turned out for installation on carriers, and more than 2,500 others for installation on the Valentine and the early Ram tanks. Both the gun and the carriage were turned out by the same plants which later built the 6-pounder gun.

The 6-Pounder Anti-Tank Gun. This compact but powerful cannon measures 18 feet over-all and weighs about one ton. Its construction is such that the gun and carriage may be taken down and re-assembled in a matter of minutes. The weapon fires an armor-piercing shell capable of penetrating the heavy armor plate of most enemy tanks. In each unit there are about 500 parts, most of which have to be processed several times. The 6-pounder at an elevation of 15° has an effective range of 2,000 yards with a muzzle velocity of 2,700 feet per second, compared with the 2-pounder with a 12° elevation, a muzzle velocity of 2,600 feet per second, and a smaller projectile.

The engineering company which turns out the 6-pounder operates in a large ordnance factory built around an old rolling mill, at Longueuil, Quebec. Only 10 months after the receipt of its go-ahead order the Company delivered, in May, 1941, its first 2-pounder and this record was repeated for the 6-pounder. It was felt that a peak monthly production of 600 6-pounders could be obtained in a reasonable time. Actually the firm reached a peak monthly production of 860 in August, 1942.

The manufacture of the 6-pounder entails one thousand operations before assembly; the breech alone requires 500. When the contract was let, there were no designs available to the contractors for the 1,200 major fixtures and items of tooling, including special tools and cutters. The firm itself not only designed the tools. but manufactured them as well.

The production achievements of this plant include the manufacture of several types of naval mountings, one of which is the quadruple mount for the 2-pounder pompom, the most complicated piece of ordnance made in Canada.

Crown investment in this plant exceeds $9 million. Even at peak, the Longueuil arsenal never employed more than 2,000 on its multi-production lines. Its output to date totals in excess of 8,000 6-pounder guns. Most of these have been installed on the special 6-pounder carriage, also built in Canada. The remainder have been mounted on Ram medium cruiser tanks. At present, the Longueuil plant is working on an order for more than 10,000 6-pounder loose barrels. Several of the complete equipments have gone to China.

The 6-pounder carriage, now out of production, has been built in a large automotive plant in Regina, Saskatchewan, in which the Crown has invested close to $4 million for the manufacture of ordnance. More than 3,500 carriages were made before production was discontinued. The plant employs in excess of 1,000 workers and is the largest war plant in Saskatchewan. It is the only Canadian plant building ordnance on the automotive industry principle of the moving conveyor. Another plant, the Crown plant at Peterborough, produced about 100 2/6-pounder gun carriages before going into production of the 3.7-inch carriage.

The 4.5/5.5 Gun Carriage. Rounding out the list of Army guns is the interchangeable carriage for the 4.5-inch field gun and 5.5-inch howitzer. This highly complex equipment is now being manufactured in the Government-owned plant of National Railways Munitions Limited, Montreal, a wartime subsidiary of Canadian National Railways. The Company is also a quantity producer of naval artillery.

This Crown company had an interesting beginning. Point St. Charles in downtown Montreal had been the site of railway locomotive shops for the previous 80 years. In 1928, the shops became inadequate for the needs of the Canadian National Railways, and it was decided to build a new plant. All the necessary buildings were

completed, except a large car shop which was held in abeyance. In 1940, when the government was seeking plant facilities to produce ordnance, it was suggested that the proposed railway car shops be constructed and operated for armament production for the duration of the war. A Crown company was set up in February, 1941, and a 260,000-square-foot factory was erected at a cost of $5 million for buildings and equipment. The construction work was so rapid that National Railways Munitions Limited was able to deliver its first weapon, a 12-pounder naval gun, on the night of December 31, 1941, one year after the first sod was cut.

The plant has completed an extensive contract for 12-pounder naval guns. It is now completing its moderately large order for 4.5/5.5 gun carriages, each of which consists of some 3,000 parts. National Railways Munitions also has on hand a substantial order for 4-inch Mark XIX naval guns, a substantial order for Twin Bofors naval mountings and a large sub-contract for fire director equipment. The plant is virtually self-sustaining, being equipped to manufacture its own jigs, tools, and fixtures.

The plant employs more than 1,000 workers. To train the employees in the intricate art of gun making, the company called on fewer than 100 skilled C.N.R. technicians from its shops in Montreal, Stratford, Moncton, Toronto, London, and Prince Rupert. These railway machinists became the supervisors, foremen, and leading hands in the munitions plant. Among the hundreds of workers are many women who have been shown how to operate turret lathes, milling machines, drills, and overhead cranes.

NAVAL GUNS

The 2-Pounder Pompom Gun and Mountings. This gun is familiar to moviegoers who have seen the "Chicago Piano," a mounting which carries eight of these anti-aircraft automatic cannons. The Vickers naval 2-pounder is a stubby gun which fires shells at the rate of 120 rounds per minute. Its particular deadliness lies in the effective way it may be installed on

multiple mounts. Each gun is belt-fed, and its jacket is water-cooled. Built in Vancouver, British Columbia, in a government-owned plant, operated by a bridge company, it is the most complicated naval gun made in Canada. Several hundred units have been turned out and production is scheduled to continue for many months. The barrels are made in the Hamilton Bofors gun plant.

More than 400 single mountings for the naval pom-pom were manufactured by a locomotive plant in Kingston, Ontario. Before the Oerlikon gun became so popular, the single mounted 2-pounder was the Navy's main defence against low flying aircraft. The mount is light in weight and may be installed on small vessels. Of an orthodox type with rivetted carriage, it has presented no serious manufacturing problems.

Quite different, however, is the quadruple mounting built in Longueuil, Quebec. At first made in a hand-operated model, it is now turned out in a power-control version which has added no less than 23 gear boxes and increased the cost of the mounting by about 50 per cent. It is the most complex piece of ordnance made in the Dominion, and costs in excess of $50,000.

The 12-Pounder Gun and Mounting. More than 1,500 12-pounder naval guns to protect merchant vessels and small ships were delivered before their production in Canada was discontinued. Along with the guns, close to 1,500 sturdy single mounts were manufactured.

The naval 12-pounder is used mainly for arming freighters and patrol vessels. With its mount, it weighs 7,000 pounds. An experiencd crew can fire its 12-pound shells at a rate of 30 rounds per minute. Of simple design, the gun and mounting are ideally suited for mass production.

Two Canadian ordnance factories, one operated by the Canadian Pacific Railways in Calgary, Alberta, the other, National Railways Munitions Limited in Montreal, have produced this gun. The Calgary shops handled two-thirds of the order, producing their own mounts. The

mounts for the National Railways Munitions Limited guns were turned out by another artillery plant in Hamilton, Canada's major artillery manufacturing centre.

The 4-Inch Naval Guns and Mountings. Canada produces two 4-inch guns, and three types of mounts, one of which comes in two models. The Mark XVI* gun goes on the Mark XIX twin mounting, the Mark XIX gun is installed on the Mark XXIII* and Mark XXIII** single mounts, and the Mark III** mount, another single, is equipped with the Mark V-c gun not made in Canada.

The two types of 4-inch naval guns manufactured in Canada are quite different one from the other.

The No. 16* is the more effective and complicated of the two weapons. It is a high-velocity gun and is capable of engaging high-flying aircraft and large surface craft. It is manufactured in Sorel in the ordnance plant which turns out the 25-pounder field gun. The No. 19 mounting which carries two of these guns is the largest single piece of armament manufactured in Canada. It is built by a Trenton, Nova Scotia, steel plant. The No. 16* guns, and No. 19 mountings, are built in Canada for the British Admiralty.

The No. 19 gun is a low-velocity gun, and is much simpler to manufacture than the No. 16*. It fires the same shell, but its barrel is much shorter, and its breech mechanism not half as complex. It is made in Montreal by National Railways Munitions Limited. The No. 19 gun is mounted on the No. 23*, and on the No. 23** single mounts, both built by the Hamilton naval gun mount factory which has also turned out the 12-pounder mounting. These mountings are familiar to all who have seen pictures of corvettes and frigates in action. They are rugged, and carry a large shield which affords protection to the gun crew. The No. 23* is installed on combat vessels, while the No. 23** goes on defensively equipped merchant vessels. The contract for 500 No. 23, original mount in this series, and built in Brantford, Ontario, has been completed.

The Mark III** is another mount for the four-inch gun. It is produced in the Longueuil ordnance plant, which builds the 6-pounder Army guns, and the 2-pounder naval pompom multiple mounts. The Mark V-c gun, which it carries, is a high-velocity weapon turned out in Great Britain. A recent additional contract for this mounting has been awarded to the Canadian Pacific Railway shops at Calgary.

The Vickers .5 Naval Machine Gun and Mounting. While this weapon would normally be classified under small arms, the size and complexity of its twin mount place it in the naval ordnance class. Only a fraction of the order for this gun was delivered by the Ottawa plant set up to produce it. Used for anti-aircraft duty at sea, the Vickers .5-inch machine gun has been rendered virtually obsolete by the Oerlikon gun, a much more efficient automatic ackack weapon which fires shells instead of bullets.

The twin mount is still in production in Canada, more than 350 having been delivered to date. Whereas the manufacture of naval mounts usually is carried out in plants which in peacetime make locomotives, or other railway rolling stock, or heavy machinery, this mount is being made in an eastern Ontario plant originally intended to be a shoe factory.

Oerlikon Twin, and Oerlikon Single Mountings. These are two naval mounts for the famed Swiss automatic gun which has revolutionized naval anti-aircraft tactics. The twin mount is produced by an automotive plant in Oshawa, Ontario, and the single mount, at first made in the same plant, is now built in Regina, Saskatchewan. More than 500 twin mounts, and in excess of 1,200 single mounts have been delivered to date. The single mount is based on the U.S. model, but the Canadian manufacturing firm, working in co-operation with officers of the British Admiralty Technical Mission in Canada, is responsible for the design of the pedestal, considerably lighter than its U.S. counterpart. The twin mount built in the Dominion also is largely an American development, although it follows the basic

Admiralty design. Its cradle and hydraulic systems were developed in Canada by British Admiralty Technical Mission engineers.

Naval Rocket Mountings. Hitherto on the secret list has been the fact that Canada has manufactured and delivered hundreds of mounts to support rocket projectors.

The rockets are carried in baskets on each side of the turret. These baskets can be tilted to control the flight of the projectiles. The mounts were manufactured in Canada in two types, one built in Fergus, Ontario, the other in Winnipeg, Manitoba. They are both out of production.

SMALL ARMS

The No. 4 Mark I Army Rifle. This weapon, of which more than half a million units have been produced, is the British Lee-Enfield adapted to Canadian production methods. It is equipped with a new-style, short-spike bayonet. It has a simplified battle backsight allowing for two normal ranges instead of the costlier adjustable backsight formerly used. Its effective range is given at approximately 1,200 yards, with a maximum range of 2,000 yards. The rifle fires single shots, the bolt which closes the chamber being unlocked and drawn after each shot to eject the empty cartridge and allow a new round to rise from the magazine. A trained marksman can fire 15 rounds per minute. The gun is made up of three main sub-assemblies—the barrel, the woodwork, and the "action"—but these sub-assemblies comprise 97 components, which require 1,000 or more operations to produce. The processing is broken down to many simple operations performed on automatic machines for maximum employment of operators without previous training.

The cost of this rifle has been cut almost 50 per cent since the first units were produced in 1941. The first units cost $62.30. At the end of 1943, the figure was $32. How production shortcuts have substantially reduced the cost of this gun is told in a sub-section of the Introduction to this volume.

The No. 4 Rifle is made in a new factory, Small Arms Limited, at Long Branch, Ontario, owned and operated by the Crown. It is headed by a young military engineer, who has been largely responsible for the development of the entire project. Small Arms Limited employs close to 5,000, of whom more than 60 per cent are women. The plant is a modern efficient factory. Its present delivery rate is about 60 rifles per hour. The total cost of plant and equipment to date has been a little over $8 million.

The plant capacity and production schedules have been steadily expanded. The project was authorized on June 6, 1940, and on October 28, while the plant was under construction, the Company was asked to treble its original schedule. At the end of June, 1941, during which month the first rifles were produced, it was further directed to schedule the output to six times the volume originally scheduled.

The Sten Sub-Machine Carbine. The parachuter's favorite weapon is this "dime store" carbine with a barrel made from ordinary tubing and a stock like a piece of plumber's pipe. This short, ugly tommy gun also is used by commandos and by the "underground" fighters in Axis-occupied territories, who receive it by parachute.

The Sten is another product of Small Arms Limited. Its manufacture calls for a surprisingly small number of employees. By the end of 1943, nearly 75,000 Stens had been produced. The output reached a peak of 8,500 per month in 1943, but owing to smaller requirements, the 1944 rate will be 5,000 per month.

Like the No. 4 Rifle, the Sten is produced not only for the Canadian Army, but also for the Air Force, and the Navy, and for the United Kingdom. The bulk of the present output is earmarked for Mutual Aid to China.

Of all-metal construction, the Sten weighs only five pounds and costs about $10. It has a rate of fire of 550 per minute. Allowing for time taken to change magazines, it can maintain a rate of fire in excess of

200 rounds per minute. It has a useful life of more than 5,000 rounds. Eight magazines holding 30 rounds each are packed with each gun. It fires 9-mm. ammunition.

The Long Branch Training Rifle. The general manager of Small Arms Limited has also designed a training rifle suitable for training new recruits in holding, manipulating and aiming a service rifle. The Long Branch training rifle is considered superior to the British equipment and is produced at one-fifth the cost. An order for several thousand units has been placed, and deliveries are well advanced.

The Cooey .22-inch Training Rifle. More than 40,000 of these small training rifles for Army and R.C.A.F. cadets have been delivered by a Cobourg, Ontario, plant. More than half as many are scheduled to be turned out by this factory. The same contractor has produced an aiming tube of .22-inch calibre to enable troops to practice with the Boys .55-inch anti-tank rifle using smaller ammunition. The order, for more than 75,000 units, has been completed.

The Bren Machine Gun. The war has proved the value of the Bren gun. Canadian-made Bren guns have seen action on every front—in Italy, Sicily, North Africa, Russia, China, Burma, the South Pacific. When the Japanese launched their attack on Pearl Harbor, Canada sent Bren guns by plane to points of attack. The Dominion has shipped thousands of Bren guns to more than 50 destinations the world over.

To the end of 1943, more than 125,000 Bren guns had been delivered by a Toronto, Ontario, plant which is said to be the largest single producer of machine guns in the Empire. The plant employs close to 15,000 of whom more than 50 per cent are women.

The government has invested more than $25 million in this vast ordnance factory. Not only have all production commitments been met and often exceeded, but the cost of the Bren machine gun has been reduced steadily since the first unit was delivered in March, 1940. The original price was $230. It now costs $160.

Weighing only 21 pounds, the Bren .303-inch is a favorite infantry weapon of the armies of the British Commonwealth. A well-trained, fast-working crew can fire steadily at a rate of 200 rounds per minute. The maximum rate is 550 rounds per minute, but the average rate under active service conditions is about 120. It is of simple design, almost foolproof, and easy to assemble correctly. The Bren is air-cooled, and gas operated. It is fired from a bipod, tripod, or from the hip. Its effective range is 1,000 yards with a maximum of 2,000 yards.

Large quantities of Bren guns are being manufactured for China.

Bren gun tripods are also produced in Canada, more than 20,000 having been delivered to date.

The Canadian method of packing Bren guns so that they arrive in perfect condition has been used as an example for British contractors.

The 100-Round Bren Magazine. Until the advent of the 20-mm. gun, the Bren was the major infantry defence against low-flying planes. Equipped with the standard 20-round magazine, it did not have sufficient fire power for this purpose. Accordingly, a 100-round magazine was designed in the United Kingdom, and close to 150,000 units were produced by a refrigerator manufacturing concern in London, Ontario. This store is now out of production, but new contracts have been awarded to the plant for a similar item.

Browning Automatic 9-mm. Pistol. This weapon, designed by a Belgian ordnance firm, is being produced in large quantities for China, in the Bren gun plant in Toronto. Its ingenious holster, created by the Chinese, is made of wood, and can be attached to the pistol grip to form a butt for firing from the shoulder. The holster is made by Small Arms Limited.

Spare Machine Gun Barrels. The Bren gun plant is also turning out hundreds of barrels for the Vickers .303-inch machine guns, and for the Browning .30-inch machine guns.

The Browning Aircraft Machine Gun. This is a .303-inch weapon and is thus of the same calibre as the No. 4 rifle and the Bren gun. It is air-cooled, and pneumatically or electrically operated. It has a terrific rate of fire—1,200 rounds per minute—and the greatest destructive power of any weapon of its calibre. The Bren gun plant delivered more than 30,000 of these weapons before discontinuing its production in August, 1943.

The month of peak production saw 3,000 Brownings delivered. After the contracts for this gun had been terminated, the plant turned out in excess of 60,000 spare barrels, and thousands of other spare components for the Browning .303-inch.

The Boys Anti-Tank Rifle. Concurrently with the Bren, and the Browning aircraft machine gun, the Bren gun plant has manufactured another gun, the Boys anti-tank rifle, a single-shot, hand-operated weapon, with simple bolt action. The calibre is .55-inch, and the rifle is fired from a bipod. It affords protection against light armored fighting vehicles. The first Boys units were delivered in February, 1942, and production terminated in August, 1943, after more than 50,000 units had been delivered. Owing to changing conditions of war, there was no further demand for this weapon. At peak, more than 6,000 a month were turned out.

The Browning Tank Machine Gun. Basically the same as the Browning aircraft machine gun, the Browning .30-inch machine gun for installation on tanks, has heavier and slightly more rugged components, and a lower rate of fire power. This weapon was made in a new government-owned $5 million small arms factory in Windsor, Ontario, operated by an automotive firm and originally set up to produce aircraft machine guns. Production of the tank machine gun started in July, 1942, and 25,000 were completed by August, 1943, when manufacture was discontinued.

The Two-Inch Trench Mortar. First made by a Toronto elevator equipment manufacturing concern, which delivered more than 1,500 units before going into production of another type of small arm, this deadly weapon fires a 2-pound bomb. The mortar is now in quantity production in a Sherbrooke, Quebec, machinery plant, which has turned out in excess of 5,000. The monthly output during 1943 was 400; this will be stepped up to 600 in 1944, maximum quantities of this efficient weapon having been requisitioned.

The Three-Inch Trench Mortar. Big brother to the two-inch mortar, the three-inch mortar was produced in Canada in the Sherbrooke factory which is now making the smaller mortar. More than 1,000 units were shipped overseas. The weapon fires a 10-pound bomb.

The Two-Inch Bomb Thrower. The two-inch bomb projector is basically the same weapon as the mortar of the same calibre, but is designed for installation on tanks and armored cars for defensive purposes or for laying smoke screens. Unlike the mortar, it consists of two sections and the bomb is dropped into the section inside the tank. The bomb is then projected out of the thrower by means of a firing device, which gives the thrower the appearance of an oversize revolver. Some 40,000 two-inch throwers have been delivered by the Toronto factory which had gained its experience in the manufacture of weapons of this type by turning out the two-inch trench mortar.

The Four-Inch Smoke Discharger. Nearly 2,500 of these large-bore smoke dischargers were manufactured by a Toronto textile machinery plant before the store went out of production during the year. The discharger looks like an elongated tin can.

INSTRUMENTS

The opponents: A German aircraft and a Bofors anti-aircraft gun. The winner: The Bofors gun. Reason: The predictor.

The predictor is an amazing device which enables an anti-aircraft shell to arrive at a pre-determined spot, thousands of feet in the air, at the same time as an enemy plane. Many intricate computations are required to achieve this result, and these must be made at lightning speed. The calculations involve numerous and complex factors: height, speed, angular deflection, influence of wind, air temperature, barometric pressure, and humidity, together with the temperature of the shell propellent and the muzzle velocity of the gun.

The predictor, which can be called "a military supercalculating machine," makes all the computations in a split second, without human aid, and transmits the solution electrically to the gun. An oil power unit control carries out the instructions instantly. Elevation and bearing are automatically set. The gun is fired, and the plane is brought down. The performance of this instrument is all the more astounding in that the target travels two miles or more during the flight of the shell. The only operation carried out by human hands is the loading of the gun.

The predictor is but one of more than 250 Army optical and other artillery fire control instruments produced in Canada. The stores range from the simple Murray rangefinder, which costs about two cents, to the predictors which consist of 1,500 precision parts and cost in excess of $5,000. Included are a wide variety of instruments requiring special techniques and the finest of workmanship.

Among the many stores produced under this program are five types of rangefinders, from the short base model at $715 to the 12-foot model at $20,000; nine types of telescopes, three types of periscopes, eight types of gun sights, 11 types of protractors, seven types of clinometers for measuring elevation, four types of collinators for correcting the adjustment of sighting instruments, five types of artillery scales, three types of prismatic

compasses, three types of directors, four types of mag-slips, two types of binoculars being produced at a rate of thousands per month, and a host of other devices including aiming posts, aim correctors and testing devices of all kinds, as well as some fifty minor stores.

This list includes Army precision instruments only, not the many other similar items being produced in Canada for the Navy and the Air Force, or the extremely varied signals and communications stores which are dealt with elsewhere in this volume.

As with guns and countless other types of war equipment, Canada had no experience in the manufacture of precision military instruments. There was no Canadian source of supply for the fine optical glass required to produce the "eyes of the gun." A Crown plant, Research Enterprises Limited, was erected to manufacture this optical glass and the assistance of the National Research Council of Canada was obtained for the manufacture of several intricate instruments required only in comparatively small quantities. But, it also was necessary to develop facilities for the production of a hundred and one other stores. Everywhere there was a lack of technical knowledge, a shortage of the right precision machines, of gear cutting and testing machines, of precision lathes, of taps and dies.

The production of the larger and more complicated items was entrusted to the large manufacturers of electrical equipment, to Research Enterprises Limited—the largest Canadian instrument plant—and even to a locomotive shop. Smaller, but oftentimes not less intricate, instruments were ordered from scores of other plants located from coast to coast, such as metal products firms, engineering works, accessories and fixtures manufacturers, and from the very few peacetime producers of fine precision instruments. The meteorological service of the Department of Transport was awarded a large contract, and some capital assistance, and is turning out

instruments. Even the Superintendent of Penitentiaries has some of his deft-fingered prisoners fabricating instruments.

Not only have Canadian manufacturers been able to meet shipping schedules, but they have, in many instances, built up substantial reserves. The quality of their products has been indicated by the extremely low rate of rejection.

The first company to receive a contract for predictors sent five technicians to England to obtain first hand information on manufacturing problems and other essential data. Their steamer was torpedoed off the coast of Ireland, and three of the group lost their lives. The other two were rescued, continued their journey, then returned to Canada with the vitally needed facts which enabled their firm to begin production in record time.

Research Enterprises Limited

Research Enterprises Limited was incorporated on July 20, 1940, to provide facilities for the manufacture of war equipment of a secret nature; and for the production of optical glass, fire control instruments, both optical and electrical, and electrical devices required by the Navy, the Army, and the Air Force. The project was in part inspired by the National Research Council of Canada, which had begun, on a very modest scale, some of the work carried out today on such a large scale by Research Enterprises Limited.

The plant of Research Enterprises Limited at Leaside, near Toronto, Ontario, is one of the largest and most modern of its kind in the world. The first sod was turned on September 16, 1940, and less than nine months later, on June 5, 1941, the first pour of optical glass was made. Constructed at a total cost of $7.5 million for buildings and equipment, it comprises a 55-acre property with 750,000 square feet of factory floor

space. It employes 7,500 persons, of whom about 40 per cent are women. The monthly payroll is in excess of $1 million.

The company has produced more than $75 million worth of optical glass, instruments, and radar equipment, and has orders on hand for an estimated $85 million more. Its optical division, last year, turned out an average of 45,000 pounds of fine optical glass per month, in no less than fifteen different types of glass. In the peak production month, 32 tons of optical glass were produced. The total output of glass to the end of 1943 was in excess of 825,000 pounds, more than 500,000 of which were produced in 1943 at the remarkably low cost of $1.08 a pound.

The production of instruments in 1943 ran at an average of 4,000 units per month, and to the end of 1943 in excess of 70,000 instruments were delivered. The first instrument produced by the plant, a prismatic gun sight, was delivered on August 20, 1941, less than two and a half years ago.

In addition to prismatic gun sights, Research Enterprises Limited turns out Indian, and sight clinometers, sighting telescopes, signalling telescopes, bearing and elevation telescopes, Vickers periscopes, binoculars, dial sights, directors, and range finders. In September, 1943, it delivered its 1,000th range finder. It also manufactures the unbelievably complicated Admiralty fire control clock, which consists of 6,000 parts, requiring intricate and finely adjusted sub-assemblies, and necessitating machining to the closest of tolerances. Each unit has 3,000 high-precision gears, and costs more than $60,000.

Indicative of the progressive business methods and production short cuts employed in this plant is the constant reduction effected in the price of the various instruments it produces. For instance, the Vickers tank periscope, first manufactured at a cost of $250, now costs only $70.

Naval Armament and Equipment

To expedite the manufacture of special naval stores, armament, equipment, and instruments, the Department created a special branch in the summer of 1940, to act as the official business agency for the British Admiralty Technical Mission, and the Royal Canadian Navy, in the manufacture of these special items.

The branch, known as the Naval Armament and Equipment Branch, co-operates with the Gun Production Branch in speeding the delivery of guns and mountings, and lets contracts for a variety of unusual naval stores. While the requirements of the Canadian Navy are usually small, the branch also handles large contracts of the British Admiralty.

Contracts let by the Naval Armament and Equipment branch for guns and mounts, plus miscellaneous items related thereto, are in excess of $100 million. In addition, the branch has placed orders for another $100 million worth of special stores, ranging from ready reckoners at $22 to complex naval gun sights at $25,000, and rangefinder-directors at $40,000, as well as the $60,000 fire control clocks made by Research Enterprises Limited. More than half the $100 million is earmarked for secret anti-submarine equipment produced for both the British Admiralty and the Royal Canadian Navy, a program on which 175 firms are engaged.

The long list of products manufactured under this branch includes several types of naval gun sights, loading teachers, fuse setting machines of several patterns, fuse keeping clocks, wind instruments, receivers, range transmission units, dumaresqs for naval fire control, range clocks, naval rangefinders, correctors, sighting gears, recorders, echo sounding devices, air lockout sights, three types of binnacles, compasses, three types of telescopes, binoculars, and many other navigational instruments and secret apparatus. This branch even handles the purchases of emergency ration containers, and ammunition trays. It supervises the production of more than 100 major items.

The branch also supervises the manufacture of 24 torpedo components for the 18-inch torpedo, and of five components for the 21-inch torpedo. Contracts for these are handled by 16 firms located from coast to coast, and total in excess of $10 million. The parts range from valve and piston rings for both types, costing between $1 and $4, to the warheads, or blowing heads, for the 18-inch torpedo, costing $1,350 each. The total cost of the Canadian-made components for each 18-inch torpedo is in excess of $5,000 yet this represents less than half the cost of a complete torpedo.

SHIPS

SLASHING through the grey Atlantic waves, hundreds of sleek escort vessels from Canadian yards are helping to keep vital ocean traffic open 24 hours a day, seven days a week. Some are serving with the Royal Navy, many more with the Royal Canadian Navy. They escort convoys in which many of the cargo ships are 10,350-tonners turned out by the shipyard workers of British Columbia and Quebec.

From the shores of Fundy Bay to the Straits of Juan de Fuca, boat-builders, from canoe makers to operators of giant freighter yards, are turning out craft for war purposes. Canadians from every walk of life answered the call for workers in these yards.

A mechanic from Estevan, Saskatchewan, took the train to Vancouver; although he had never seen a ship

before, in less than six weeks he was a welder working on a cargo vessel hull. A young Toronto lawyer joined the staff of a Montreal yard, and started helping to build corvettes. From the Laurentians came a farmer to work in the Sorel shipyards. While at Halifax, a housewife joined a local yard to do her bit in the war effort.

These are typical of the thousands who have added their efforts to those of the small nucleus of experienced shipbuilders available at the beginning of the war. Today, together with those employed in the ancillary and component industries, they total in excess of 100,000, and turn out virtually every type of craft afloat from a lifeboat to a destroyer. Their production includes patrol boats, minesweepers, corvettes, frigates, several types of cargo ships, special purpose vessels, and an assortment of smaller craft.

The Canadian shipbuilding program is a major phase of the war effort of the United Nations. It contemplates an expenditure of more than $1 billion. To date, more than 1,000 ships have been delivered, including naval craft, cargo ships, and a variety of special-purpose vessels. In addition, many thousands of small craft have been completed. This production has come from a country in which shipbuilding has been dormant for more than 20 years and where, prior to the war, only nine berths were available for the construction of large vessels.

Towards the end of 1943, various changes were effected in the shipbuilding program. These will result in a slight decrease in the output of cargo ships during 1944. But this decline will be more than offset by the greater number of combat ships which will be built during the year, in spite of contract cancellations. The fighting ship schedule for 1944, both in tonnage and dollar value, far exceeds that of 1943. In addition, the naval yards will also produce large landing vessels each costing in the neighborhood of $1.5 million.

The Canadian shipbuilding industry is spread across the breadth of the land. Ships are being built thousands of miles from the sea—on the Great Lakes and on the St. Lawrence River. Components are being manufactured in more than 300 plants from coast to coast.

From 14 fairly large yards with limited facilities and about 15 smaller boatworks, at the outbreak of hosilities, the Canadian shipbuilding industry has grown to 25 major and 65 smaller yards. Existing yards have been greatly expanded and graving docks, piers, machine shops, marine railways, and a large floating drydock capable of berthing two seagoing vessels at one time, have been built for ship repairs. An efficient organization with all the necessary equipment for ship and cargo salvage also has been set up.

In the first quarter of 1940, some 4,000 men were engaged in the construction of vessels and small craft. By the end of 1940, 17,000 men were at work in the yards. Late in 1941, the total was 22,000. By the middle of 1942, it was 40,000, and by January, 1943, it had reached 50,000. The peak was attained in mid-summer, 1943. when more than 75,000 men and women were at work in all Canadian yards, exclusive of those employed by various contractors supplying components.

Eleven major shipyards, and four outfitting yards, are building fighting vessels. Five smaller yards are producing other types of steel vessels, including tugs, lighters, and oil tankers. Sixty smaller boatbuilding plants are turning out small craft. Eight large shipyards are delivering 10,000-ton cargo vessels, and four others, 4,700-ton freighters. Two of the latter turn out both combat ships and merchantmen. A few other major yards are busy on the Dominion's extensive repair program.

Towards the end of 1943, Canadian shipbuilding activities were administered as follows: The Naval Shipbuilding Branch of the Department supervised the construction of fighting ships, special vessels, and small craft. The Controller of Ship Repairs administered the overhaul of damaged vessels, the salvaging of sunken shipping, and the building of destroyers. A Crown company, Wartime Merchant Shipping Limited, supervised the cargo vessel program. Another Crown company, Trafalgar Shipbuilding Company Limited, was charged with expediting the priorities for the naval shipbuilding program. With the exception of the

government-owned Toronto Shipbuilding Company Limited, all shipbuilding was carried out by privately owned companies, although the activities of three yards in the Quebec area were co-ordinated by Quebec Shipyards Limited, a Crown company. Another Crown company, Park Steamship Limited, operated the majority of cargo vessels and tankers built in Canada.

At the turn of the year, 1943-44, Toronto Shipbuilding Company Limited was surrendering its charter. The active management of the yard was left in the hands of a private company under the direction of Wartime Shipbuilding Limited.

To make possible a more efficient utilization of shipbuilding capacity and to maintain adequate supervision over both naval shipbuilding and cargo vessel construction, in December, 1943, it was decided to merge the administration of the cargo boat program with that of the naval shipbuilding program. Wartime Merchant Shipping Limited, renamed Wartime Shipbuilding Limited, added the supervision of combat ship construction to its cargo shipbuilding activities, while the Naval Shipbuilding Branch, under the appropriate redesignation of Shipbuilding Branch, was entrusted with the over-all administration of the entire shipbuilding program, including the management of, and direct supervision over the extensive wooden hull and small craft program.

Directory of Canadian-built Ships

The following are the main types of ships being built in Canada:

Cargo Ships—10,350-tons: Length, 441 feet. Beam, 57 feet. Depth, 37 feet. Draught, 27 feet. Deadweight, 10,350 long tons. Engines, triple expansion, 2,500 h.p. Speed, loaded, 11 knots. Crew, 40, exclusive of gunners. Four types: North Sands, Victory, tankers, and Canadian.

4,700-tons: Length, 328 feet. Beam, 46½ feet. Depth, 25 feet. Draught, 20 feet. Deadweight, 4,700 long tons. Engines, triple expansion, 1,176 h.p. Speed, loaded, 10 knots.

Destroyer—Tribal class: Length, 377 feet. Beam, 37½ feet. Depth, 21½ feet. Displacement, 2,000 tons. Engines, turbine driven. Speed, 36½ knots. Armament: six 4.7-inch guns, two 4-inch guns, multiple pom-pom anti-aircraft mountings and several Hurricane guns; one set of quadruple torpedo tubes, controlled from bridge. Crew, 240 men, including 17 officers.

Frigate—Length, 307 feet. Beam, 38½ feet. Engines, triple expansion reciprocating. Twin screws. More powerfully armed, faster than the corvette, but details of armament and equipment are still secret.

Corvette—Length, 208 feet. Beam, 33 feet. Depth, 17½ feet. Displacement, 1,170 tons. Engine, triple expansion reciprocating. Single screw. Armament, one 4-inch gun, machine guns and depth charges. Operates over a wide area.

Algerine Minesweeper—Length, 225 feet. Beam, 35½ feet. Displacement, 1,000 tons. Engine, triple expansion reciprocating. Armament, naval gun and machine guns. Carries depth charges. Crew, more than 60 men. Employed for both escort work and minesweeping.

Fairmile Patrol Boat—Swift fighting craft, 112 feet in length. Wooden construction. Carries crew of 17. Powered by two gasoline motors. Armed with a naval gun, machine guns, and carries depth charges.

The other main types comprise: Two types of wooden minesweepers, both more than 100 feet long; 3,600-ton tankers, invasion ships, landing craft, invasion cargo barges, tugs, and more than 100 types of other special-purpose vessels and small craft.

Naval Shipbuilding

The need for ships, particularly of the naval escort class, became manifest immediately after hostilities began in September, 1939. When the War Supply Board was created, a shipbuilding division was established to handle all matters pertaining to the procurement, repair, and conversion of vessels, barges, small boats and other craft for the Canadian and Allied governments.

When the Department of Munitions and Supply superseded the War Supply Board, in April, 1940, the shipbuilding division of the board became a branch of the new Department.

In 1939 the shipbuilding industry in Canada was practically non-existent. While there were a few shipyards capable of building fairly large vessels, no ships of the seagoing type had been built between the two wars. Records show that in 1935, a typical pre-war year, the Dominion was turning out only 4,336 tons of shipping annually and fewer than 4,000 men were employed in the yards. Canadian industry had never been called upon previously to supply machinery, auxiliaries, fittings and materials for naval ships.

By February, 1940, contracts had been awarded to 15 shipyards for 64 corvettes and 14 steam-driven minesweepers to cost $47 million. At the end of that year, 16 more corvettes and 50 more minesweepers had been ordered, increasing the commitments to $79 million.

Every possible source of labor was tapped to meet the pressing need for all the trades involved: Platelayers, blacksmiths, rivetters, welders, joiners, machinists, and so forth. Yards were hurriedly reconditioned and the technical staffs worked day and night to prepare for the job.

During the first stages, hull plates, channels, and angles had to be imported from United States steel mills. Ten keels were laid during February, 1940, beginning a construction program without precedent in Canadian history. By the end of the year, 44 corvettes had been launched and 15 delivered, in addition to nine minesweepers launched, and more than 250 smaller craft delivered.

Month by month, Canada's shipbuilding program was extended. Early in 1941, contracts were placed for an additional 16 corvettes and 10 minesweepers similar in type to those under construction. By mid-summer, contracts had also been negotiated for 16 Western Isles minesweepers, and other types of ships. Then a new naval shipbuilding program was introduced involving

the construction of improved single-screw corvettes, of frigates, and of a new type of larger minesweeper. A redistribution of work in the various naval yards was arranged, some being switched over to the cargo ship program then being initiated.

During 1941 the demand for naval vessels and merchant ships, together with the need for more extensive repairing and refitting facilities, became so pressing that it was deemed advisable to set up separate agencies for each activity. Thus, the Shipbuilding Branch was relieved of two programs; a Crown company, Wartime Merchant Shipping Limited, was formed to control the building of merchant ships, and a separate Controller of Ship Repairs and Salvage was appointed.

From then on, the Naval Shipbuilding Branch took charge of all naval vessel construction in Canada, other than the destroyer program; all non-naval shipbuilding with the exception of merchant shipbuilding; the construction of miscellaneous craft such as small boats, barges, landing or assault boats, and bridge pontoons; the purchase and chartering of existing vessels and negotiation of compensation for such vessels; capital assistance for any of the foregoing purposes; the administration of the emergency ship repair agreement, and the negotiation of an occasional repair or conversion agreement normally outside of its scope.

With the fame already won by the corvette to spur them ahead, Canadian naval shipbuilders had now added the frigate and the algerine to the line of escort ships under construction. These are much larger, faster, and more powerful than the corvette and the original steel minesweepers turned out in Canadian yards. Frigates are more than 300 feet long, compared to the corvette's 208 feet. They are more heavily engined and armed. Their construction requires much more craftsmanship than cargo vessels, which are turned out more or less on a mass production basis. And frigate engines and boilers are built to provide double the power required in the larger merchant vessels.

In 1941, to offset a threatened bottleneck in the supply of materials, the governments of the United

States and Canada established a priority system to ensure that war requirements, in order of their importance, would receive preference.

This move involved the creation of a negotiations division and a production division within the Shipbuilding Branch, and the employment of engineers, who were specialists in the machinery, hull steel, electrical fitting, and valve trades. Shortly thereafter purchase orders were placed by the branch instead of by each yard individually.

As an example, there were at that time several Canadian firms making valves. These companies were being called upon to produce not only the 1,500 valves per vessel for naval ships, but also the valves for the cargo ships, and the requirements of the other services and of industry generally. As valves vary greatly in size and kind, line production was limited to comparatively small quantities; and the plants were not organized to take care of the large wartime orders. So, at a time when there was more than enough business for all, each manufacturer was carrying on in the old way. Thus each firm received a portion of all the valve business, and each continued to produce a full range.

The same condition prevailed with electrical fittings, and somewhat similar conditions obtained in the machinery and steel trades. It was apparent that manufacturers of components had to be organized to manufacture in accordance with the collective vessel-by-vessel building schedules of the different yards, and that new sources of supply for many items had to be secured.

When the Shipbuilding Branch took over the purchasing of all supplies, it was arranged not to order valves for naval ships from manufacturers engaged in supplying valves for cargo ships, and vice-versa. The pulp and paper, and mining industries were asked to employ their machine shops to turn out valves and valve parts. The rationalization of component manufacturing resulted in a substantial increase in production.

In the electrical field, the main contractors spread their orders between 35 firms who operated as sub-contractors, and orders were placed in quantity lots which allowed for suitable tooling-up for speedier production.

The manufacture of engines was well organized and accelerated.

In order to secure the required production facilities, several firms making components were granted capital assistance to a total of $5.5 million for the purpose of extending their plants and equipment. In other instances, manufacturers financed their own additional facilities.

To implement the naval shipbuilding program itself, the building capacity of each yard was increased in some instances by extending the number of building berths and adding new plant, and in others merely by the addition of new plant. Capital assistance amounting to $7.5 million was provided for these extensions. A new type of contract, on the basis of cost plus a fixed fee per ship, was arranged to stimulate production. Training schools for improving the efficiency of shipyard employees were opened, and organizations set up to improve technical and engineering methods. Thus, naval shipbuilding continued to increase rapidly.

In shipbuilding, as in the other major war production programs, 1943 was a year of records. During the last quarter of the year alone, 12 frigates, eight algerines, nine corvettes, nine patrol vessels, and three wooden minesweepers were delivered.

A red letter day in Canada's shipbuilding history was September 18, 1943, when twelve vessels were launched in Canadian yards, comprising the Tribal destroyer, H.M.C.S. Mic Mac; two frigates, a corvette, an algerine, a patrol vessel, a tanker, two large freighters, and three other utility vessels.

To the end of 1943, Canadian naval yards had delivered 26 frigates, 104 corvettes, 91 steel minesweepers, 34 wooden minesweepers, and 77 Fairmile patrol boats, a total of 332 combat ships completed out of 400 launched. In addition, 24 motor torpedo boats had been built.

The total value of steel combat vessels delivered in 1943 was in excess of $70 million, an increase of 75 per cent over 1942. In 1943, the emphasis switched from corvettes and small steel minesweepers to the larger, more efficient, and costlier frigates and algerines. In the wooden combat ship program 40 patrol vessels and minesweepers were delivered.

The production of combat craft, however, is not the only achievement. Scores of smaller shipyards and boat-works are turning out wooden and steel craft for every imaginable purpose. Ship deliveries in 1943 included 44 tugs and two 168-foot auxiliary tankers. The program for 1944 calls for the delivery of six 3,600-ton tankers and more than 100 tugs.

Of a wide variety of special-purpose vessels on order, more than 40 had been delivered by the end of 1943. These included base and supply ships, concrete and wooden gate vessels, a floating dry dock, steel and wooden derrick scows, as well as ammunition and store lighters, transport and salvage barges, salvage and supply vessels, steel water tanks, tenders, target towing vessels, and large railway barges. These special craft range from 75 to more than 150 feet in length.

The production of medium-size landing craft is very large. To date 800 of these craft have been delivered.

Of more than 4,000 other small craft, with or without power, on the shipbuilding program, 75 per cent have been delivered. These include a surprising variety of all types such as dinghies of several lengths, cutters, whalers, lifeboats, pontoons, and assault boats.

Other activities of the Shipbuilding Branch included: the purchase and conversion of passenger liners to armed merchant cruisers at a cost of $6 million; outfitting merchant vessels with defensive equipment; the purchase of trawlers, yachts, and small fishing vessels and equipping them for minesweeping operations; and the provision of additional drydocking facilities on the Atlantic coast at a cost of $4.5 million, and the arrangement of additional handling facilities at different ports.

Cargo Shipbuilding

With Dunkirk and the fall of France, with the great losses of shipping in the Atlantic, and the necessity of maintaining her lifeline from North America, Britain was forced to take immediate steps to restore and increase her Merchant Navy. In this emergency she turned to North America. In September, 1940, a Technical Merchant Shipbuilding Mission left the United Kingdom to place contracts for large tonnage in United States shipyards, and to investigate the possibilities of cargo shipbuilding in Canada.

Not more than nine berths of 10,000-ton deadweight capacity existed in the Dominion. Shipyards were immediately organized, and the Shipbuilding Branch, which was already having naval ships built for the Royal Canadian Navy and the Royal Navy, undertook the supervision of this work. The first keel was laid in the early spring of 1941. On April 4, 1941, a Crown company, Wartime Merchant Shipping Limited, was incorporated to supervise and administer the program, which had developed to major proportions. On December 21, 1941, the first cargo ship, S.S. Fort Ville-Marie, was delivered.

The success of the program has been a triumph of Canadian industrial organization and co-operation. At the end of the last war, because much of the equipment and machinery was imported, the Canadian content of Canadian-built ships ran to about 35 per cent. Wartime Merchant Shipping Limited faced serious import problems. It was necessary, therefore, to arrange with more than 300 contractors and sub-contractors to make parts of ships and equipment, and machinery of various types and sizes, on a scale never before undertaken in this country. Geographically, the job covered industrial Canada from coast to coast. Testifying to the co-ordination achieved, no ship completions have yet been delayed because of the non-arrival of any necessary equipment or machinery.

The Crown company also has made steady progress in curtailing the use of critical materials in cargo ship construction. All imported woods have been eliminated.

Substitution and redesign have saved seven tons of brass and copper and 1½ tons of tin in the construction of each ship.

The present steel cargo shipbuilding program, under which 374 merchant vessels of two main types will be built at a cost of well over $500 million, exceeds that of the last war by a wide margin, in the number, in deadweight tonnage of ships delivered, and in the speed of construction.

Cargo ships of the tonnage required can be built in Canada only on the Pacific coast, in the St. Lawrence River up to Montreal, and in the maritime provinces. Vigorous action stepped up the construction of new berths, and by June, 1942, their number had grown to 51.

Ships began slipping down the ways at a rapidly increasing pace until in 1943 they reached a figure of three a week. As the yards and workmen acquired experience and increased their output, records were achieved. Thus, the first cargo ship required 210 days to deliver, although later one ship was delivered 58 days after the keel was laid.

When it began operating, Wartime Merchant Shipping Limited assumed the responsibility of administering the contracts placed with Canadian shipyards by the British authorities. Negotiations were immediately opened to place new orders on behalf of the Canadian government.

Initial orders placed with the various yards totalled 88 cargo ships of the North Sands type, and six 4,700-tonners of the William Gray type. These contracts were placed with shipyards on the east and west coasts, and in and around Montreal, a thousand miles from the sea.

The types of ships required had been decided upon by the authorities in the United Kingdom who originally were to man and operate them under the British Ministry of War Transport. There were two main types. The more important was originally known as the 9,300-ton deadweight North Sands with a length between perpendiculars of 416 feet. The other was a 4,700-ton Gray type with an over-all length of 328 feet.

Although basic plans for both these types also were prepared in England, numerous modifications have since been necessary. Changes were required first of all to adapt the basic plans to Canadian construction methods, to conserve critical materials, and to utilize substitute materials. Then changes had to be made from time to time to conform to the continually altering naval regulations and the requirements of wartime operations.

The improved North Sands are of 10,350 tons deadweight, and 439 feet long. They are coal-burning vessels, powered with Scotch marine boilers, and triple expansion reciprocating steam engines.

Built for immediate war requirements, the North Sands type was chosen because the components are suited to mass shipbuilding, and the ship itself is suitable for construction in all types of shipyards. The engines and boilers are of rugged construction, simplified for operation by persons of limited experience, and easy to repair and maintain in all ports of the world. The vessel is able to carry all types of cargo—general merchandise, crated motor vehicles, bulk grains, coal, ore, lumber, or munitions of all types, ranging up to the heaviest of guns and tanks.

More than 100 of these ships are being built as oil burners, with the necessary changes in design and equipment. They are called Victory ships.

Based upon Canadian experience in building North Sands ships and Victory ships, another type of ship of improved design and known as the Canadian, is being built. One of its characteristics is adaptability for either coal or fuel oil, which under post-war conditions will give it much greater operating flexibility.

The 4,700-ton freighters are intended for moving general and bulk cargo to ports where the volume of trade is not large and where the water is comparatively shallow. These ships, originally designed for British operations, are now being modified to meet Canadian operating conditions. They are most suitable for Canadian coastwise trade, and also to supply Labrador, Newfoundland, and the West Indies.

The majority of the war freighters built in Canada are named after historic Canadian forts. The remainder are given the names of well-known Canadian parks.

By the middle of 1943, Canadian shipyards were launching 12 cargo vessels per month. By the end of the year a total of 219 large and 13 smaller freighters had been delivered. Cargo ships on order, under construction, or delivered, total 374, of which 36 only are 4,700-ton ships.

The problem of obtaining parts and components was not confined to naval shipbuilding. Wartime Merchant Shipping Limited also had to tackle it. For example, engines and propellers for larger cargo ships had never been built in Canada and their production had to be arranged.

Systematic control of the production of components eliminated competition, and thus substantial economies were achieved. The company eventually took over the purchasing of more than 50 major components, such as main engines, line shaftings, boilers, super-heaters, auxiliaries, windlasses, winches, steering gears, propellers, electric generators and electric generating sets.

Capital assistance was provided where necessary to speed up the program, both for yards which required it, and for some of the component manufacturers.

Ship Repairs and Salvage Control

During the summer of 1940, pressure on shipbuilding plants was almost exclusively for new naval construction. But in the autumn of the same year, the ship repair situation began to assume great importance. It became evident that the question of priority in the matter of ship repairs in Canada for the United Nations was a concern of the Dominion government.

It was necessary to regulate and co-ordinate the ship repair industry, to settle priority procedure between the various shipping interests, and between merchant shipping and naval vessels.

Therefore, on November 27, 1940, the official occupying the post of Director General of Shipbuilding was also appointed Controller of Ship Construction and Repairs.

Later, with the need for ship repairs increasing rapidly, it was deemed advisable that the Ship Construction and Repairs Control should thereafter devote its time exclusively to matters connected with the repair of ships, including the construction, maintenance, and use of dry docks. The Controller moved to Montreal, and his Deputy made his headquarters in Halifax.

This move was effected in April, 1941, and the Control then became known as Control of Ship Repairs. During the following winter, substantial progress was made. The Control was authorized to spend $7 million in providing equipment and facilities to enable large vessels to be repaired with a minimum of delay. Plans were undertaken for the erection of a floating dry dock, wharves and wharf extensions, marine railways, machine shops, piers, graving docks, concrete docks, and suitable repair shops.

During 1941, it was decided that Canada should commence building larger naval craft, such as destroyers, and the Controller was given the responsibility for this program. In the latter part of the year an order was placed for four Tribal class destroyers. In the early summer of 1942, the first keel was laid in Halifax, and the first vessel was launched on September 18, 1943.

In the early days of the war, procurement of supplies from Canadian and United States sources was comparatively simple. As ship repair stockpiles and ship chandler's warehouse stocks began to diminish, and critical materials in Canada and the United States were earmarked for special munitions work, it was found necessary to establish a ship repair priority assistance division of the Control.

In October, 1941, a procedure was set up whereby all priority applications for ship repair materials should be channelled through the Control. This brought the Control into intimate contact with ship owners, ship agents, shipyards, drydock operators, machine shops, foundries, ship salvage operators, cargo salvage operators, and ship insurance agencies, to expedite the movement of ships and their cargoes, and to assure quick action in the event of disasters in Canadian waters.

Early in 1942, ship salvage became an acute problem and the Control, again changed in name, assumed responsibility for this problem. Thereafter known as the Ship Repairs and Salvage Control, it was given authority to employ emergency measures in connection with rescue work as well as to salvage ships and cargoes. To stop the illegal sale of salvaged material to unauthorized persons and to provide compensation in a legal manner to fishermen turning salvage over to the Receiver of Wrecks, the following procedure is now observed: Nothing is taken off a wrecked or grounded vessel without authority; salvaged material is held by the finder only until he can notify the Receiver of Wrecks for the area; fishermen turning salvage over to the Receiver of Wrecks are given a receipt and, after the value has been appraised by the Customs Department, they receive an award from the government.

Ship salvage operations have been conducted on an impressive scale and many valuable cargoes have been reshipped to original destinations or channelled into Canadian war industry. Salvage services are arranged and supplied by private operators. The direction of the operations centres in the Control.

Some of the most colorful and interesting war work being conducted in Canada is that of this Control. For security reasons, many of the details of the operations cannot be disclosed. But the importance of the work is obvious. Keeping ships serviceable, afloat, and at sea, is as important and as effective as ship construction.

The growth of ship repair activities has been even more rapid than the growth of the naval and merchant fleets. One facet of these activities illustrates their scope: Canada is spending $15 million each year to refit, and to provide the latest detection and other devices for, the Royal Canadian Navy ships built two or three years ago.

The Control arranges for repairs and maintenance of ships of Allied nations as well as those of the Empire. From January, 1940, to December, 1943, Canada repaired 25,000 naval and merchant vessels, and during the same

period 5,000 of this number were drydocked for major overhaul or examination.

The ship repair facilities are manned by 15,000 Canadian shipyard workers and machine tool operators.

Toronto Shipbuilding Co. Limited

The Toronto Shipbuilding Company Limited was incorporated as a government-owned company on October 21, 1941, to operate a Toronto shipbuilding company purchased by the government. It acquired the waterfront property of the Dufferin Paving Company and leased adjacent land from the Toronto Harbor Commission to expand existing facilities of the original yards by 50 per cent. After delivering many Bangor class minesweepers, this yard is engaged in building minesweepers of the algerine class. It employs more than 3,000 workers.

Most of the minesweepers are completed and delivered in Toronto, but a few are completed in outfitting yards in Hamilton, Ontario, and Saint John, New Brunswick.

While this company is now surrendering its charter its management remains unchanged and, like the other yards, operates under the direction of Wartime Shipbuilding Limited.

Quebec Shipyards Limited

In line with the Department's established policy of reducing cost of operations and accelerating production, Quebec Shipyards Limited was incorporated as a government-owned company on June 16, 1943, to co-ordinate the shipbuilding activities of Morton Engineering & Dry Dock Co. Limited, Quebec City; George T. Davie & Sons, Limited, Lauzon, Quebec; and the shipbuilding division of the Anglo-Canadian Pulp and Paper Mills Limited, Quebec City.

The company was established to simplify and correlate production programs of escort vessels of the three shipbuilding plants. The group of yards is building and outfitting corvettes and frigates, while two are building 4,700-ton freighters in addition to naval craft.

The Park Steamship Co., Limited

The control and operation of newly-built Canadian cargo vessels carrying munitions and supplies to the theatres of war is administered by Park Steamship Company Limited, a government-owned company incorporated on April 8, 1942.

The company takes over new merchant ships and allocates them to the ocean routes where they can best be utilized to carry Canadian-made supplies to the United Nations.

Advice as to the allocation of vessels to the various trades is received by the company from the Canadian Shipping Board. As the Park Steamship Company does not operate any vessels, all ships are turned over to steamship companies to manage under an approved agreement. The allocation of vessels to the various shipping companies for management is made by the directors of the Park Steamship Company. The managing operators are directly responsible to the company in respect of the care of the vessels and of financial results from the voyages made.

Supplying crews is the responsibility of the managing operators. Assistance is secured from the Directorate of Merchant Seamen, which maintains manning pools throughout Canada for this purpose. Virtually all men and officers are secured through this source.

During the war, the size of the Park Steamship Company will be limited only by the number of Canadian crews that can be obtained. After the war, the ships now being chartered to the United Kingdom will be returned to Canada and added to the Canadian merchant fleet.

At the end of 1943 the company had in operation: 37 10,000-ton dry cargo ships; five 10,000-ton tankers; 13 4,700-ton dry cargo ships; one dredge converted to a small tanker. In addition delivery was taken from builders of 84 10,000-ton dry cargo ships and turned over to the British Ministry of War Transport under Mutual Aid.

Trafalgar Shipbuilding Company Limited

Early in the war no control was exercised over the allocation of available materials, supplies and manufactured goods, essential for ship construction.

Later, when the governments of the United States and Canada enacted regulations by which each end-purpose, for which goods or materials were required, was given a priority rating according to its importance in the war effort, the construction of cargo and naval ships was accorded very high priority rating, and a Crown company was formed to administer all priority arrangements for the Shipbuilding Branch.

Trafalgar Shipbuilding Company Limited, the agency, was established as a government-owned company on August 7, 1941. Having served its purpose, it was dissolved towards the end of 1943. It had been created by the Department to expedite the shipbuilding program. Its directors were officers of the Shipbuilding Branch, and while possessing other powers, it operated solely as the agency through which shipbuilders and their subcontractors made all priority arrangements. In a similar manner, it secured certificates of essentiality where British goods were concerned, and maintained direct contacts with the U.S. Priorities Board, through a representative officer resident in Washington.

Wartime Administrator—Canadian Atlantic Ports

Owing to the great increase in population of Halifax, Nova Scotia, that port became so congested that the smooth functioning of the war program was likely to be impeded. To cope with this situation, a Wartime Administrator of the Port of Halifax was appointed in May, 1942. He was given authority to exercise full control over all activities and operations of the port.

Later the Administrator's powers were expanded to cover all Atlantic ports, and in November, 1943, his powers were further augmented to enable him to take additional measures to relieve the congestion and the unsatisfactory living conditions resulting therefrom.

The Administrator co-operates with other authorities in solving problems such as: Housing and population congestion; hospitalization for seamen; dock facilities; cargo tonnage and merchant ship movements; waterfront operation; security against fire hazard; ballast unloading; stevedoring; and railway freight handling.

SIGNALS AND COMMUNICATIONS

ALTHOUGH only sixth in dollar value in the list of Canadian war products, the output of signals and communications equipment and supplies must rank near the top as a contribution to the war program of the United Nations.

The reason does not rest in the fact that up to the end of 1943 nearly 10,000 orders had been completed, but rather in the fact that because of her own particular genius Canada has been made responsible for many types of secret apparatus on which the fighting forces must depend for the successful outcome of every battle.

In 1940 the production value of all such signals and communications devices and supplies stood at only $1

million. In 1942 it was $60 million, as compared with a $16 million annual turnover of the radio and electrical industry before the war. In 1943 it had reached $136 million, or approximately as much as Canadians spent each year in peacetime on new automobiles and trucks. Orders on hand now total some $400 million, of which $226 million worth are from other countries, and peak production will not be reached before the second quarter of 1944.

Canada is blessed with excellent research facilities, and with engineers and workmen receptive to new ideas and forthright in translating such ideas into quick action. From all parts of the country come inventions and new methods of manufacture, and no time is wasted in checking these inventions and methods to separate the wheat from the chaff. Familiar with mass production techniques, Canadians are able to tackle and overcome almost insurmountable problems in quickly turning out new and complex apparatus on a mass production basis. Yet Canadian manufacturing experience is such that it provides the necessary flexibility to cope with rapid, sometimes revolutionary, changes in design—changes which in many instances have been launched before even so much as a pilot model has been made.

Thus it was natural that Canada should become a major producer of the types of electrical apparatus still highly secret, and that much of the Allied production of other, more familiar types of equipment also should become her responsibility.

Some twenty major types of radar equipment have been developed for a variety of applications, ranging from one type for anti-aircraft defence having 60,000 components, and 270 radio tubes, mounted in several large trucks, to small compact airborne units used for submarine detection at sea and target location on land.

Canada has had a major part to play, not only in the production, but also in the development of this radar equipment. Working in close co-operation with the British and U.S. investigators, the National Research Council has made a noteworthy contribution to the practical application and fuller utilization of this revolutionary device.

The task of making the equipment on a mass production basis fell on the shoulders of a Crown company, Research Enterprises Limited, which had been established early in the war to produce optical glass and instruments.

The techniques and methods of manufacture of radar were entirely unknown. New buildings had to be erected, new staffs trained, and new designs worked out to fit in with North American components and manufacturing practice. New and highly complex components had to be obtained from the already hard-pressed private manufacturers. Yet in spite of these serious handicaps, the company was able to achieve a truly substantial output within a comparatively short time.

Besides supplying the armed forces of this country with nearly 100 different types of signals equipment, and with thousands of types of components and supplies, Canada is sending signals and communications equipment and supplies to the United Kingdom, the U.S.S.R., China, India, Africa, New Zealand, and Australia, for service in every theatre of war. Even the United States, despite its great productive facilities, depends on Canada for large quantities of signals apparatus.

At the close of 1943, there were approximately 4,500 different items in production by some 50 prime contractors and several hundred sub-contractors. Wireless sets and their components make up the bulk of production, but the contract list covers the entire range of modern communication devices from telephone and telegraph supplies to the latest and most secret apparatus. On that list are such things as amplifiers, antennae, cable, radio compasses, remote control units, signalling lamps, power generators, quartz crystals, 25 types of radio receivers, 23 types of radio transmitters, 19 types of transmitting and receiving sets, six types of telephones, several types of switchboards, and scores of types of radio tubes.

In one day Canadian factories now turn out 300 miles of field cable, six cable layers, 100 amplifiers, 200 control units, 100 signalling lamps, 200 charging sets, 50 generator sets, 50 switchboards, 200 transmitter-receivers, 100

radio receivers, 25 radio transmitters, 100 installation kits for vehicle receivers, 100 wavemeters, and hundreds of other pieces of equipment, both large and small.

Some of the types of wireless equipment are as highly complex as a small peacetime radio station, others no more difficult to make than an inexpensive radio. One in particular will illustrate the problems which must be overcome by the maker. Known as wireless set No. 19, it comprises three separate channels of two-way communication: one for speech by wire telephone among the crew of the vehicle on which it is mounted; one for radio telephonic communication with nearby vehicles; and one for radio telegraphic or telephonic communication between vehicles or between itself and fixed stations over distances of many miles. The three systems of communication must be capable of simultaneous operation.

This general-purpose vehicle wireless set is used to equip many of the tanks and armored fighting vehicles, and thus in point of volume is the most important signals device being made in Canada for the Allied armies. Adapted from British designs and re-engineered in this country, the sets are being made in two large Canadian plants at the rate of several thousands monthly. The development of a set of this kind presents difficulties never encountered by designers of civilian radios. A set built for use in an Army tank must withstand temperature variations from 50 below zero to 150 degrees above. It must operate under varying power conditions, withstand jolting and pounding and, in addition, must combine compactness with simplicity of operation.

Similarly, aircraft communications equipment must operate equally well on the ground and at high altitudes under quickly varying conditions of temperature. Marine equipment must be specially designed to withstand corrosion and humidity, and must also be designed to prevent radiations which might betray the location of the ship.

A wireless set may include transmitter and receiver units, power units, generator sets, charging sets,

batteries, earphones, microphones, remote control equipment, antennae, insulators and spare parts. One type of vehicle set has 6,000 parts. For each of these parts the manufacturing schedules provide a number of essential spares, plus first and second year maintenance bulk spares, so that spares production alone runs into astronomical figures. The maintenance and repair of signals equipment is a major production and supply problem in itself.

Canadian-made signals apparatus must withstand laboratory tests that would reduce the average commercial radio to wreckage. All new sets are subjected to field trials under simulated service conditions. The necessity of making military equipment as compact as possible, while retaining maximum strength and efficiency, adds to design and production difficulties. Few types of war production present so many problems or require so much hand work. The Canadian Army maintains its own experimental establishment where development is carried on, but much of the spadework is in the hands of contractors assisted by departmental experts. On Navy and Air Force projects such work is carried out almost entirely in the manufacturing plants, under the supervision of skilled engineers from the respective services.

All phases of the production program are co-ordinated by the Signals Production Branch. The bulk of the output comes from the Canadian radio industry, which has expanded its volume tremendously since the outbreak of war; from other electrical equipment manufacturers; and from Research Enterprises Limited.

The success of the program is largely dependent upon hundreds of small parts for assembly in the larger factories. Scores of these plants have been converted from non-essential production just as the radio industry itself has been converted completely from civilian radio output to war production.

The Department of Munitions and Supply has borne the necessary tooling expenses on contracts for equipment manufactured from government designs, has

furnished capital assistance for expansion and conversion, and lends expediting assistance whenever production may be delayed for want of critical materials and supplies.

Canadian industry proved its ability to meet the rigid requirements of service specifications when a trial order for 200 British No. 1 radio sets was placed in Canada in 1935. Much of the signals equipment now being made in the Dominion has been adapted from British designs and re-engineered to suit Canadian manufacturing methods and facilities. A good deal of groundwork was necessary before the first large orders for military communications apparatus could be placed after the outbreak of war, but the program got well under way in 1941 when $15 million worth of equipment was produced.

The design and development of most major pieces of equipment have now been stabilized. Any new developments will be carried out jointly by Canada, Great Britain, and the United States in the interests of standardization and interchangeability.

At the request of the armed services, the Signals Production Branch has undertaken to act as a co-ordinating agency for the standardization of all radio component parts. The value of this program—under way since August, 1943—in elimination of waste, in a fuller utilization of labor, and in simplification of manufacturing problems, cannot be overstressed. To date, 15 major studies have been completed, resulting, for example, in 256 types of radio tubes being reduced to 56, 31 kinds of paint being cut down to four, and 50 types of microphones and headsets replaced by three, to mention but a few.

Defence Communications Limited

In addition to the production of equipment and in addition to the arrangements made with communication companies themselves, to supplement communication facilities which had been developed for peacetime requirements, the Department has been building an extensive and co-ordinated communication system in

eastern Canada for the armed services through the agency of Defence Communications Limited, a Crown company which commenced operations in April, 1943.

This company was charged with the responsibility of making a complete survey of the existing communication facilities in eastern Canada and of co-ordinating such services with an expansion program requiring substantial additions to the present facilities to meet the requirements of the armed services in this area. It provides telegraph, telephone, teletype and wireless facilities for the three services, chiefly by arrangements with commercial operators, and has built new facilities over a very extended area at a cost of about $3 million. The use of carrier current equipment installed by Defence Communications Limited as part of this program has made it possible to utilize the existing facilities of the commercial operators to the greatest possible extent, and has also made it possible to conserve many thousands of telegraph poles and approximately two million pounds of copper wire, which otherwise would have been necessary for the additional facilities required by the armed services. The carrier equipment installed permits the superimposition on existing circuits of three voice channels and one teletype circuit or, alternatively, two voice channels and from one to 12 teletype circuits.

Communications Division

The complex communications system of the Department of Munitions and Supply, which late in 1943 was transmitting a monthly average of some 65,000 government messages to and from points all across Canada and into Newfoundland and the United States, had its beginning in a single, British-leased circuit between Ottawa and New York City.

With the outbreak of war, procurement orders from Britain to this continent had to be handled with great speed and in secret. At first such orders were routed through the High Commissioner of the United Kingdom in Canada by direct cable and transmitted by the British purchasing authorities in Canada to the manufacturers of this country and, through the British representatives

in New York, to the U.S. manufacturers. On January 2, 1940, the British purchasing authorities in Canada leased a direct circuit between Ottawa and New York City so that they could maintain rapid, secret communication with the British representatives in that city.

By July, 1940, it was decided that the Canadian Department of Munitions and Supply should assume the task of purchasing for the British in this country, and that purchases for Britain in the United States would be entirely in the hands of the British Purchasing Commission in that country. Immediately thereafter, the Department of Munitions and Supply decided to establish its own Communications Division as a part of the Secretary's Branch, and thus to co-ordinate the despatch, distribution, recording and filing of messages.

On July 15, 1940, the Department took over the operation of the British-leased Ottawa-New York teletype circuit, and on August 16, 1940, installed a "drop" which connected Montreal with this circuit. Later, however, the traffic became so heavy that a duplex circuit was established between Ottawa and Montreal. A circuit to Washington was put into operation on May 19, 1941.

But these additions did not prove sufficient. During 1941, when production was expanding rapidly, an analysis of communication costs revealed that the Department would save public funds if additional circuits were installed. Accordingly, during January, 1942, the Department leased teletype circuits and opened offices in Toronto and Hamilton, Ontario, to provide service between these two cities and Ottawa. Shortly thereafter, at the request of the Inspection Board of the United Kingdom and Canada, the Department extended its circuits to serve the artillery proof establishment ranges in Hamilton, Ontario, and Valcartier, Quebec, and the Inspection Board offices at Cherrier, Quebec City, and Bouchard in Quebec province. Because of the increasing volume of business between the Department and the manufacturers of armored vehicles, circuits were opened to Oshawa and Windsor, and to serve plants engaged in making and filling shells,

similar circuits were established to Scarboro, Pickering and St. Catharines, all in Ontario. Detroit was connected to the Windsor circuit.

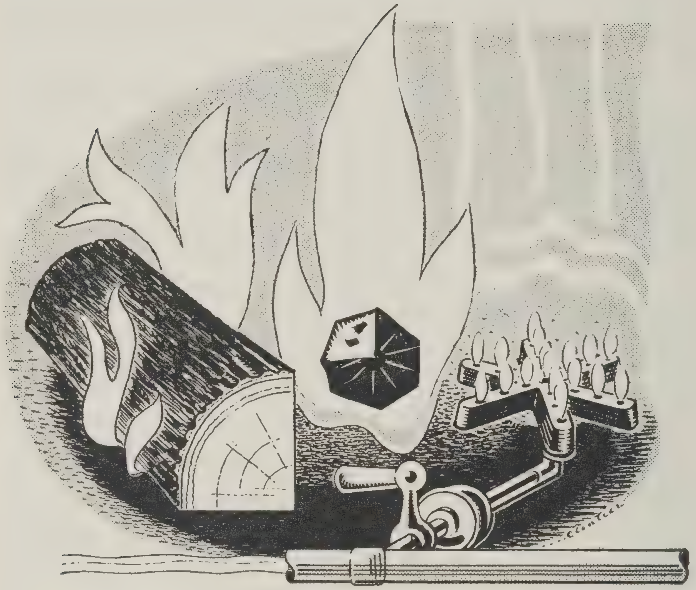
During May, 1943, arrangements were completed with the Department of National Defence for Air for the reciprocal use of the teletype facilities of the two departments. This greatly extended the service available from the Communications Division, providing for direct contact with points from the west to the east coast of Canada and also to Newfoundland.

Thus by the close of 1943, the Communications Division was providing non-commercial teletype service to three points in British Columbia, one in Alberta, one in Manitoba, sixteen in Ontario, fourteen in Quebec, four in New Brunswick, seven in Nova Scotia, one in Prince Edward Island, four in Newfoundland, and four in the United States. The traffic had grown from about 2,000 messages per month in 1940 to 75,000 in December, 1943. Cable traffic in the same period had grown from 584 to 2,251 messages per month, and outgoing commercial telegrams from 1,225 in March, 1941, to 2,751 in December, 1943, after reaching a peak of 4,572 in January, 1943.

In addition to serving the Department itself and departmental contractors, the teletype service was made available to certain representatives of other Commonwealth governments and Allied missions, and more recently to all other Dominion government departments.

Late in 1940, the Department arranged with the Department of National Defence for the use of the radiotelegraph service operated by the Department of National Defence. Thus, without cost to the Department, messages could be sent to most of the principal cities in Canada and Newfoundland but, as such messages were broadcast in much the same manner as ordinary radio broadcasting, confidential and secret messages could not be dispatched over these facilities.

To reduce the cost of long distance telephone communications, the division, in October, 1940, leased a private circuit to Montreal and a second such circuit to Toronto.



SOLID FUELS AND GAS

THANKS largely to a mild autumn, to a conservation program, and to efforts made by the government to stimulate the production of both coal and firewood, the fuel position in the winter of 1943-44 showed substantial improvement over the previous year.

This country has comparatively large natural resources of coal, and immense resources of standing timber. Yet fuel shortages provided the worst home-front headaches during 1943, and with war demands continuing at a peak the prospects of plentiful supplies in the next twelve months are not good.

In normal times Canada uses 30 million tons of coal per year, plus about 10 million cords of bushwood, substantial quantities of slabwood, and thousands of tons of sawdust, and mill waste. In addition, billions

of cubic feet of gas, hundreds of thousands of gallons of fuel oil, and some electric power are employed for heating.

Even after allowing for the success of the conservation campaign, the coal consumption for the year ending March 31, 1944, will be approximately 47.25 million tons, a new Canadian record. At the three-quarter mark in the coal year (a coal year is the twelve months ending March 31), approximately 70 per cent of this requirement had become available. Stocks of anthracite coal for household use were low.

Because of efforts to encourage local bodies to undertake their own wood cutting, and because of subsidies and government cutting projects, the firewood position at the beginning of 1944 had improved. Virtually all the southwestern Ontario gas production was diverted to war industry and thousands of homes and buildings in that area were switched to coal or wood. In some areas electric power was in short supply and its use for heating was discouraged.

The fuel situation, therefore, was serious, but not as serious as it was during the extreme winter of 1942-43, when blizzards, high winds, sub-zero cold, and absence of the usual thaws, combined with extraordinary industrial demands to boost consumption to a new all-time high. Partly because of this rise in consumption and partly because heavy snowfalls and deep drifts interfered with deliveries of wood and coal, various communities suffered hardships.

In one western city during the winter of 1942-43 three schools were closed for nine days. In an eastern Ontario village, fences, doors, and even old furniture were burned. In a Georgian Bay municipality an alderman, himself a wood fuel dealer, was unable to obtain firewood for his own use. In a large Ontario city no solid fuel was available until small quantities of soft coal, earmarked for local war industries, were released to the public. The citizens made their way through a driving snowstorm to queue up at coalyards, where they were doled out lots of 100 to 200 pounds.

In one far western city many householders were without fuel of any kind and had to move into hotels or into the homes of friends and neighbors. In a large central city, coal was rationed in small lots, which the householder had to pick up himself at the nearest fire station.

These instances were, of course, extreme, but the shortages were more or less general throughout the country. That the hardships were of short duration was largely the result of quick action by the Coal Control in diverting available supplies of coal and wood to communities where they were most needed. Later steps prevented a recurrence of such hardships.

Coal

Coal is much more than a basic heating agent which keeps the home, the office, and the factory warm. It is the mainstay of the metals industry, on which the whole scheme of living is based. It is the source of power for many factories, most railway trains, and most steamships. In addition, it is a treasure store of useful chemicals which heal the body, add a touch of glamor to women's attire, and perform an Arabian Night dream of transformations into thousands of war and essential civilian articles.

When gas is made, coke and coal tars are produced. From the coal tars come thousands of compounds including dyes and medicinal preparations such as the famous sulpha drugs. Coal is a base for the manufacture of nylon, a necessary silk substitute from which parachutes are made. It goes into chewing gum, into plastics of many kinds and, if need be, into synthetic fuel. As gas it cooks foods and hardens steels. As toluol it is a base for bomb-filling explosives. And as coke it is one of the two chief requirements for the production of iron and steel.

Canadian consumption of this vital commodity has risen rapidly since the outbreak of war. In 1939-40 a slightly under-average total of 28.5 million short tons was used. Two years later the total was 41.5 million, and for the last coal year it was approximately 44.4

million. The requirements of the current coal year are estimated at 47.25 million tons. The consumption increase since 1939 has been approximately 70 per cent.

During this same war period, domestic production has risen, but to an extent much smaller than the proportionate increase in consumption. As a result, Canada has had to rely very largely on imports from the United States, and such imports have doubled in the past three and a half years. The requirements of the United States itself have risen enormously since the entry of that country into the war, yet in spite of labor difficulties U.S. production also has increased, and exports to Canada have been maintained at a generous level.

Early in 1943 the coal situation was so unsettled that a disastrous shortage was feared. However, the government took steps to boost production, and at the same time plans were laid for the conservation program which later proved so successful.

Of the estimated 47.25 million tons needed for the year 1943-44, 4.3 million are anthracite, 18 million are bituminous and lignite produced in Canada, and the remaining 24.95 million are bituminous from the United States. During the first eight months of the coal year, 54.5 per cent of the Canadian production, 80.7 per cent of the estimated bituminous requirements from the United States, and 70.8 per cent of the estimated American anthracite requirements had become available, as well as some 300,000 tons of anthracite from Britain. By agreement with the United States, anthracite requirements were reduced from the 1942-43 peak by 10 per cent, a similar cut having been made in the United States.

Canadian Coal Production and Consumption

Although in recent years no hard coal has been produced in Canada, the production of soft coal has been sufficient in peacetime to supply about half the total coal requirements for the whole country.

Soft coal is mined in Nova Scotia and New Brunswick in the east, and in Saskatchewan, Alberta and British

Columbia in the west. Very small quantities are surface-mined in Manitoba. The three maritime provinces and the four western provinces are thus more or less self-sufficient.

Quebec and Ontario, the greatest consumers, do not produce coal. In normal times they depend on large importations from the United States, substantial supplies from the Maritimes, and smaller shipments from the west and from the United Kingdom. In 1939-40, for example, 3.5 million tons left the Maritimes for Quebec and Ontario, and in 1940-41, some 3.4 million tons. In 1941-42 about 270,000 tons of Alberta domestic coal were used in Ontario households and some 600,000 tons of bituminous by railway divisions in the same province. Today, however, the movement from the west has ceased, and the movement from the maritimes has been drastically reduced. The importations from Britain are now only about one-quarter of what they were in 1940-41.

Maritime Provinces—Nova Scotia and New Brunswick together comprise one of the chief Canadian sources of coal. Normally they produce about eight million tons a year of a good-grade bituminous coal.

The peacetime market was chiefly for industrial, railway, and household use in the three eastern seaboard provinces, but from two to three and half million tons were shipped each year to St. Lawrence ports. To offset the economic disadvantage of the long haul, Dominion government subsidies were paid.

Before and immediately after the outbreak of war, coal from Cape Breton, in Nova Scotia, was moved by boat during the summer up the St. Lawrence River to Montreal for immediate use and to tide industries over the season of closed navigation on the river. When shipping space became urgently needed for war freight, it was necessary to find some means of releasing these colliers without altogether ending the movement of Nova Scotia coal to central Canada.

Coal can be carried by rail from Cape Breton, but it has to pass over the Gut of Canso, which separates the island from the peninsular mainland. The car ferries

were already heavily loaded with shipments from the maritime provinces and with steel for the Canadian war effort, and thus it was impossible to handle any great increase in traffic across the strait.

To overcome this bottleneck, an unloading and trans-shipping pier was constructed at Point du Chene, near Shediac, New Brunswick, and the Cape Breton coal was shipped from Sydney, Nova Scotia, in lake freighters, to this point and then transported by rail.

Speed was important. The plans for the coal-handling facilities were drafted in April, 1942, and work commenced early in May. All that existed at Point du Chene was a wharf and a branch line of the Canadian National Railways serving the lobster industry and summer residents. The wharf had to be strengthened to accommodate coal towers, the lobster factories had to be moved, acres of storage ground had to be graded and rolled, and new railway tracks had to be laid and old ones moved.

There was no time to wait for the fabrication of new coal towers. Instead, the engineers rebuilt two pulp-handling towers which they discovered at Trois Rivières, Quebec. They found a 500-kilowatt turbo-generator and auxiliary machinery at Midland, Ontario, and from Moncton, New Brunswick, they obtained two locomotive boilers to supply the necessary steam. With these make-shift facilities, they had the plant in operation on August 8, 1942, at a rated maximum capacity of three shiploads a day.

The only maritime coal problem thereafter was production. In the best month of 1942, the mines of Nova Scotia and New Brunswick had an output of 768,000 tons. From this it might be deduced that their annual capacity is about 9.2 million tons. Instead, the all-time peak was reached in 1940-41, when not quite 8.4 million tons were mined. Since then production has dropped steadily. In 1941-42 it was slightly more than 7.9 million tons, and in 1942-43 a little less than 7.26 million. The current annual rate is less than 6.2 million, and the shortage is so acute that some coal is being shipped from the United States to Halifax to supply a portion of the ship bunkerage and railway demand in that area.

Apart from shipping problems, the most important reason for the falling production has been the loss of efficient manpower in the mines, chiefly to the armed services. Up to the end of last March about 3,500 men had left the industry in the two maritime provinces; at present the shortage amounts to about 1,500, of whom 1,000 would be producing miners.

The distribution of the maritime coal is no longer on the same basis as in peacetime. In round figures the 1939 output was 7.52 million tons. In that year 1.415 million tons went to the railways for locomotive use, and of this 800,000 tons were supplied to the railways operating in Quebec. Other maritime users, both industrial and household, consumed 2.193 million tons; Quebec and Ontario absorbed 3.102 million tons; Newfoundland and the United States took 126,000 tons; ship bunkerage used 310,000 tons; and the coal mines themselves required the remainder for their operations.

Most notable feature of the wartime distribution change has been the drop in shipments to Quebec and Ontario. In 1942 approximately 1.334 million tons went to the railways, and of this only about 120,000 were used in Quebec. Other Quebec shipments totalled about 1.497 million tons; exports were about 411,000; bunkerage about 149,000; and industrial and household about 3.403 million. The balance was consumed by the collieries. Preliminary estimates for 1943 showed an even more drastic drop in shipments to the central provinces.

Quebec and Ontario—With the exception of some maritime coal shipped to Quebec points, the requirements of the two great central provinces must now be met almost entirely from United States sources.

To a lesser extent this was true even before the war. In the last full year of peace, for instance, only 30 per cent of the needs of Quebec and Ontario were filled from the western provinces, the maritime provinces, Britain, Indo-China, and Europe.

Whereas in the three eastern seaboard provinces and in the four western provinces household needs are closely bound up with those of industry, in that both

types of consumer burn local soft coals, an opposite situation exists in Quebec and Ontario. In the central provinces the railways and industry generally use American bituminous, and the householder generally uses hard coal. In 1940-41, for example, the industries, railways and coke plants of Quebec and Ontario used more than 13.66 million tons of soft coal. In the same year the householders of those provinces consumed roughly 1.3 million tons of British anthracite, largely in buckwheat size for blower use; 2.5 million tons of U.S. anthracite; one million tons of coke; and some 100,000 tons of Alberta domestic coals.

With the industrial expansion which followed the Nazi conquest of France, the picture changed. To supply blast furnaces and for other industrial uses, virtually all the coke was withdrawn from household use, and only very recently has any been made available for that purpose. British anthracite imports fell to some 300,000 tons, Alberta coal was all required in the west, and imports of American anthracite rose to a peak of 4.5 million tons in 1942-43. In the current winter more anthracite could be used, but shortages in the United States have made it necessary for the government of that country to reduce the exports to Canada by 10 per cent. With most central Canadian householders using a proportion of soft coal, with general acceptance of the conservation program, and with the advantage of a mild autumn in some areas, the reduced supplies should prove adequate.

In addition to coal consumed by ships operating on the Great Lakes, the combined consumption of Quebec and Ontario for the past three years has been:

	1940-41	1942-43	1943-44 (Est.)
Household	6,013,802	8,088,227	8,500,000
Industrial	5,662,966	7,505,868	8,000,000
Coke Plants	3,063,019	3,226,422	4,200,000
Railways	4,935,004	6,763,172	7,000,000
Totals	19,674,791	25,623,689	27,700,000

Western Provinces—The four western provinces all mine coal but, unlike the Maritimes, they produce different coals for different purposes.

Saskatchewan has lignite fields, many of which employ mechanical surface mining methods. Alberta has domestic sub-bituminous as well as bituminous mines. And British Columbia has bituminous mines both in the Crow's Nest Pass area and on Vancouver Island.

The output of the bituminous mines in the prairie and mountain regions is mostly used by the railways, while that of the coastal region supplies local British Columbia requirements ranging from household to bunkering, from export to coke making. The Saskatchewan lignite and Alberta sub-bituminous are sold in screened sizes for domestic heating and in fine sizes for steam production.

Under ordinary conditions the western mines produce sufficient coal to supply all the needs of western Canada, to export some 170,000 tons to the United States, to provide about 150,000 tons for bunkering, and to ship into Ontario substantial quantities of railway and household coals. Chiefly because of unprecedented bunkerage demands, but also because the severity of the winter of 1942-43 bit into the already scanty supplies of sawdust and mill waste used for heating private dwellings, the coastal mines have been unable to supply all local requirements. As a consequence, 322,000 tons of Alberta coal were shipped to the coast in 1942-43 as compared with only 130,000 tons during the previous coal year.

But this extra demand from the coast has not been the only difficulty faced by the Alberta and the B.C. mountain mines. They have also had an increased demand from the states of Oregon and Washington, and have been up against a drop in production caused by a loss of manpower. In the best month of 1942, the mountain mines produced at a rate of 7.5 million tons a year, but by November, 1942, this monthly output had fallen to a rate of less than 5.5 million tons a year, and since then has continued at a comparatively low level.

Normally the mountain mines sell their output as far east as Kapuskasing, Ontario, for industrial use, and Jackfish, Ontario, for railway use. Their deficit as

between supply and demand forced the substitution of U.S. coal for railway use as far west as Saskatoon and Regina in Saskatchewan, and for industrial use as far west as Winnipeg, Manitoba.

Although the Saskatchewan lignite mines and the Alberta sub-bituminous mines also lost many of their men, their 1943 production actually increased. This was because they remained in operation throughout the summer. However, the heavy demands in the west, including extraordinary requirements of the United States armed forces on the Alaska highway and of Canadian armed forces, left barely sufficient to meet the needs of the prairie householders.

History of Coal Control

The history of control over coal dates back to the first Great War. In some respects the situation in the critical year of 1917 paralleled that of today: Coal was in short supply, manpower was scarce, and transportation services were up against difficulties. But there the parallel ends.

In the first Great War prices had skyrocketed and a degree of inflation was presenting serious problems. Coal was not controlled until July 12, 1917, when a Coal Controller was appointed. In this war, both prices and coal were placed under government surveillance within six weeks after the declaration of war against Germany.

The control of the last war had jurisdiction over coal, wood, and gas. From its disbandment on March 31, 1919, there was a gap of three years until 1922, when a coal strike south of the border again brought the Canadian fuel situation to the fore. As a result of this strike, and after study of the final report of the wartime control, which had recommended its establishment, a Dominion Fuel Board was set up on November 25, 1922.

At first the new board was charged merely with the duty of investigating the Canadian fuel position, but when the government later decided to assist the producers, the administration of this assistance also became a function of the board.

Within 24 hours after the Nazis invaded Poland, the government set up the Wartime Prices and Trade Board, whose function was to provide safeguards against increases in the selling prices of fuel, food, and other necessities of life, and to assure adequate supplies and equitable distribution of these commodities. On September 14, 1939, the Dominion Fuel Board drew up a memorandum for the W.P.T.B., recalling the fuel difficulties of the previous war and outlining a program of action.

A little more than a month later a Coal Administrator was appointed. He was given broad powers to stimulate production of coal in Canada, to increase imports from Britain, and to regulate the purchase, shipment, allocation, and distribution of coal, coke, firewood, and other solid fuels.

The first step taken by the Administrator was to license all dealers in coal and coke, and to demand of them details of stocks, sales and prices.

To overcome administrative difficulties which soon arose, the duties, functions, and staff of the Dominion Fuel Board were transferred to the Coal Administration on June 25, 1941, and the Administration thus undertook the responsibility for applying the act which provides assistance to plants producing household coke, for administering the act which grants a bounty to Canadian coal for iron and steel manufacture, and also for administering the various orders-in-council authorizing aid in the movement of Canadian coal.

When the Department of Munitions and Supply was faced with rising demands for coal for the armed services, the Administration was given the task of deciding the type and source of the coal to be supplied for this purpose, and of integrating such demands with those of the country at large. In the heating year 1941-42 some 985,000 tons were provided for the three services. The figure rose to 1.35 million tons in 1942-43, and is expected to reach 1.5 million in the current coal year.

In its early days the chief function of the Administration was the maintenance of reasonable prices and supplies for the householder. Not until the late fall and early winter of 1942 did a real shortage of industrial coal develop.

By early in 1943 the chief problem had become that of supply. Accordingly, jurisdiction over the production and supply of coal, coke and wood fuel passed from the Wartime Prices and Trade Board into the hands of the Wartime Industries Control Board on March 5, 1943. The order-in-council effecting the transfer at the same time created the Coal Control, which took over the powers, duties, and functions of the Coal Administration, including the continued operation of the Dominion Fuel Board. All supply orders of the Administration became orders of the new Control.

When it was evident that the fuel shortage was becoming increasingly serious, the Prime Minister declared in the House of Commons a state of national emergency in regard to coal. On the heels of this declaration the now-famous order-in-council, P.C. 4092, was passed on May 17, 1943, and shortly thereafter the Coal Control was relieved of the responsibility for wood fuel.

The order-in-council provided that, except by permit, no employer, other than a coal mine operator, may retain in his employ any man who since 1935 has had two years or more of experience in coal mining, nor may any such employee remain in any employment other than coal mining unless he has permission to do so.

Under the order, the men thus released from industry were to be returned to the mines through National Selective Service, a branch of the Department of Labor. It was also provided that no coal miner may leave his job, nor may an operator discharge a miner, except by permit from National Selective Service, and no coal miner may join the armed services either by enlistment or by draft before February 1, 1944, except by similar permit. Additional clauses allowed the employment of boys of 16 or over in underground mining, and of women of 18 or over at surface work.

In addition, it was arranged that National Selective Service would refer to the coal mines suitable non-skilled men called up under compulsory labor transfers, and that the Department of National Defence would grant leave to all soldiers volunteering to return to such mines.

Scattered strikes occurred in both eastern and western Canada, and in the fall of 1943 a serious walk-out tied up the mines of Alberta and British Columbia. When, in November, the government authorized a $1 a day wage increase and certain other more favorable working conditions, the strike came to an end.

But strikes in coal mines were not confined to Canada. In April, 1943, the United States bituminous mines went on strike. Steps were taken at once to freeze all deliveries of such coal in both the United States and Canada. The unsettled conditions in both bituminous and anthracite fields dragged on from month to month with small work stoppages from time to time, and both the U.S. and the Canadian freezing orders were suspended or reimposed as conditions warranted. After many thousands of miners had struck in October, 1943, the United States government took over the mines, settled the dispute, and successfully encouraged increased production.

Despite these U.S. strikes, and the lateness of the opening of lake navigation, the flow of coal from across the border has been maintained at a comparatively high level. From April 1 to November 27, 1943, Canada imported some 19,616,100 tons of bituminous coal as against 17,349,400 tons in the same period of the previous year. As compensation for the lateness of its opening, the navigation season lasted longer, and thus it was possible by the end of 1943 to bring in the required tonnage of U.S. bituminous.

In previous years, at the urging of the Coal Administration, many industries built up large stockpiles, and thus when the strikes took place they had ample supplies. To offset an expected deficit between supply and demand in the United States, a policy was laid down in both countries under which industries were allowed to purchase only enough coal to last until May 15, 1944. Thus industry was forced to use up inventories.

Coal Control has found it necessary to issue few orders. When the prospects appeared blackest, in July, 1943, a restriction on the basis of 100 per cent of the previous year's consumption was introduced in Ontario and Quebec as a temporary measure. The order provided

that no householder in those provinces could buy more coal than he purchased for the previous year, and that unless the householder was willing to use high volatile bituminous for one-quarter of his proved requirements, he would not be allowed to buy for the current season more than one-half the hard coal he used in the year ended June 1, 1943.

This order was rescinded in November of the same year, and in its place an order was issued restricting household deliveries in any part of Canada to not more than one ton to a customer, and permitted no deliveries to a householder who already had enough to last 15 days or more. The order also made it mandatory to accept for consumption any type of coal which the dealer might have available, provided it was suitable for the customer's heating equipment.

Within a few days the strike situation which had inspired this order was settled, and it was possible to allow regional control directors to ease the application of the order to meet local needs. In December, however, the Control was still concerned over the possibility that some householders might not have sufficient coal for immediate needs, and the dealers were ordered to give delivery priority to those who had on hand less than seven days' supply.

To meet the emergency, it was decided early in 1943 that a coal conservation campaign would be launched, and a division of the Control was set up for this purpose. In August, 1943, an order was issued which put teeth in the campaign by making it an offence to waste fuel or heat. The order defined what type of positive or negative act would be regarded as waste.

With the slogan, "Save one ton in five," the conservation campaign urged householders to take all possible steps to insulate their homes, to avoid wastage of water and heat, and to employ proper firing methods. With the assistance of a national conservation committee, industrial users were approached, and in several instances whole groups, such as theatres, agreed to notable savings.

Emergency Coal Production Board

To stimulate the production of coal in Canada, the government established an Emergency Coal Production Board on November 23, 1942. Situated in the same offices, and with the Coal Administrator (now also Coal Controller) as its chairman, the board has been able to work hand in hand with those responsible for controlling coal.

Up to the end of 1943, the board had assisted 70 coal mine operators to maintain or increase production. This assistance took the form of recommendations as to man-power for the mines, production subsidies to keep certain mines in operation, development subsidies to increase production from old fields and open up new mines, and arrangements for special depreciation allowance for income tax purposes to make some developments financially possible. In addition, the board gave priority and financial assistance to operators to obtain machinery, and to build homes for miners.

Wood Fuel

Canadian householders depend largely on firewood to heat their homes. Throughout the country 46 per cent burn wood, as against 42 per cent who burn coal.

About nine-tenths of the fuel-wood cut in Canada is felled by farmers or by small operators employing up to ten men. Those so employed do their cutting in their spare time, or during the off-season of the agricultural year. Although such operations are small, they are so numerous that they add up to about 10 million cords in an ordinary year. Fuel-wood accounts for about 37 per cent of the total quantity of timber cut for all purposes.

In addition to fuel-wood, Canadians also burn a substantial cordage of slabwood, which comprises the side and end pieces of logs cut in sawmills. In peacetime, thousands of cords of such wood could not be economically marketed in communities far removed from the sawmills, and were burned at the mills. In 1943 a government transportation subsidy made it possible to distribute much of this wood for household and industrial use. In British Columbia about 25,000 householders burn sawdust, and thousands of others there and elsewhere burn mill waste.

Ordinarily fuel-wood is felled during the winter, cut in four-foot lengths, drawn to the roadside or some other convenient shipping spot, dried during the summer, and hauled to a dealer's yard, or direct to the consumer, in the autumn. The drying is very important.

A log of unseasoned wood weighing 100 pounds, when dried will weigh only about 66 pounds. This means that the green wood contains about one-third water by weight. If the green wood is burned, the water must be converted into steam, and the heat to accomplish this conversion is lost.

Because of the manpower shortage, the wood cut during the winter of 1941-42 was insufficient to meet the demand in the following winter. When the supply of seasoned wood became exhausted in some sections, the green wood cut for the winter of 1943-44 had to be burned, and thus the shortage was projected into another year.

Partly because of the 1941-42 production drop, partly because record sub-zero temperatures and high winds caused a sharp rise in consumption, and partly because blizzards, cold, and deep snow interfered with deliveries, many communities suffered hardships from the shortage of the winter of 1942-43. To aggravate the situation, coal and other fuels were scarce in many places.

For those who burned slabwood, sawdust, and mill waste, the situation was equally serious. The severity of the winter, and the manpower shortage, adversely affected log and lumber production and reduced the output of the sawmill by-products.

But the winter of 1942-43, with its unusual lack of a January thaw and its record snowfall, had another effect on the fuel situation. Unable to drive their horses through the deep snow in the woods, the comparatively few men available for wood-cutting were unable to begin felling the supply of bushwood for the winter of 1943-44 until late in the spring.

As a result, the government found it necessary to urge local bodies to provide for cutting operations throughout the summer of 1943. In many communities arrangements were made by the municipal council to purchase stock-piles from the usual channels, in a few centres the citizens

themselves cut wood from lots arranged for by government or local groups, and other communities brought in wood from a distance, the government paying a transportation subsidy to make this possible.

To stimulate production, the government decided early in March, 1943, on these measures:

1. A subsidy of $1 per cord was to be paid to dealers on all commercial fuel-wood contracted for and cut on or before June 30, 1943, (this date was extended later), and held to dealers' account on that date.

2. A transportation subsidy also was to be paid whenever necessary.

3. It was agreed that the government would, on request, repurchase from dealers at dealers' cost all commercial fuel-wood on which the $1 subsidy had been paid and which was still in dealers' hands on May 31, 1944.

4. Assistance would be given in providing priorities for necessary equipment.

5. Farmers then on the farm and who left the farm temporarily in response to this appeal to engage in fuel-wood cutting would be deemed by National Selective Service to be carrying out their regular occupation as farmers and would be given all the rights of deferment of military service which such an occupation entailed. Such temporary absence was not to interfere with agricultural production.

Until early in March, 1943, the jurisdiction over wood fuel was in the hands of the Wartime Prices and Trade Board under the Coal Administration. Shortly after the transfer of the responsibility for wood and coal from the W.P.T.B. to the Wartime Industries Control Board, the Coal Control was relieved of the responsibility for wood fuel, and a new Wood Fuel Control was established early in June.

One of the first acts of the new Control was to extend the period for payment of the $1 per cord subsidy to December 31, 1943, and later to March 31, 1944. It was also provided that the transportation subsidy would apply on the carriage of slabwood.

The Wood Fuel Control also took immediate steps to arrange for cutting fuel-wood under its supervision. Conscientious objectors, Japanese internees, and war prisoners were employed in a number of operations, and in two projects pulp and paper companies, under contract with the government, utilized their facilities to fell and cut large quantities. It is estimated that from all these operations, which extended across the country, about 500,000 cords were made available.

In addition to these measures, the Control undertook, through the Wartime Prices and Trade Board, to establish ceiling prices for the producer as well as the distributor, and arranged a new subsidy system under which the producer, dealer, and consumer were all assured fair treatment. This had the effect of stimulating production and distribution through normal channels, and was likely to go far toward preventing a repetition, in the winter of 1944-45, of the shortage of the previous year.

Gas

Natural gas is so plentiful in the Turner Valley of Alberta that it is used for household heating, as well as for cooking, and for industrial purposes. To a lesser extent the same thing is true of southwestern Ontario, and small quantities are also produced near Moncton, New Brunswick. Today the Turner Valley wells and the Moncton wells are still providing enough for local requirements, but southwestern Ontario has been in short supply.

In southwestern Ontario gas comes from natural gas wells, from light end gases sold by a Sarnia company which draws from a refinery in that city, and from the coke plants of Hamilton, the steel city. With the advent of greatly increased industrial activity in the Niagara Peninsula and the southern half of southwestern Ontario, the normal Ontario consumption of about 10 billion cubic feet of natural gas per year rose to nearly 13 billion in 1941. At that time some natural gas fields completely played out, and others showed signs of exhaustion. At this peak capacity, insufficient was available to continue supplying industrial requirements and at the same time provide enough for household use.

When a crisis appeared imminent early in 1942, the Power Controller arranged for the installation of new facilities, such as propane plants. At the same time householders using gas for heating were urged to change to coal.

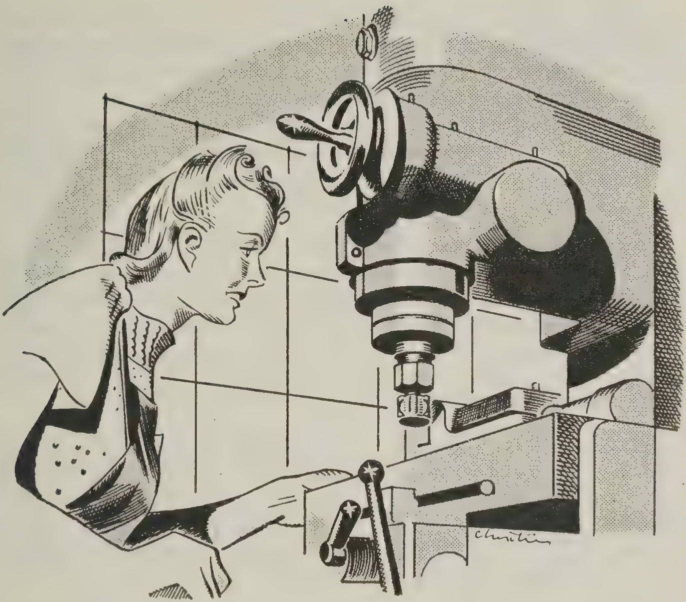
Despite some degree of voluntary reduction, the gas situation continued to deteriorate, and it became necessary to adopt restrictive measures. By a series of orders, each more drastic than its predecessor, in the period from February to September, 1942, the Control ordered several thousand owners of buildings, including dwellings, to switch from gas to coal for heating and steam production. No new installations were allowed. The owners affected were all within the area south and west of a line drawn roughly from Hamilton Bay to Galt to Sarnia.

These orders eased the shortage to some extent, but not enough. Meanwhile, however, the earlier expansion plans of the Controller were beginning to bear fruit. A still gas plant was installed during the summer of 1942 at the oil refinery in Sarnia. The still gas was pumped to gas wells and stored against winter demand. A method of mixing propane gas with natural gas was developed, and propane gas plants were erected at Windsor, Brantford, and Hamilton.

In addition, the construction of a new coke oven gas plant was begun at Hamilton. Its 36 ovens were completed by the spring of 1943, but even this added capacity was not enough, and 18 more ovens were installed. With the completion of the 18 additional ovens in December, 1943, the situation eased somewhat.

As a result of these various measures to expand production, the annual output of gas in southwestern Ontario rose by about four billion cubic feet.

The drastic orders compelling the switch-over from gas to coal were administered in such a way as to keep the unavoidable hardship to a minimum. Many householders sought exemption on the grounds of ill health, old age, or for other reasons. Permits to continue using gas were granted as far as possible to those who proved that extreme hardship would result if they were obliged to change to coal.



MACHINE TOOLS

MACHINE tools are the basic tools of industry. Famous as "machines that make machines," they not only reproduce themselves but turn out manufacturing machinery for any and every type of industry. They are used in 80 per cent of the work involved in the manufacture of guns, ammunition, cartridge cases, bombs, Diesel engines, instruments, and countless other items required in the prosecution of the war.

The technician describes a machine tool as a stationary, power-driven, metal-working machine which has one or more cutters and work-holding devices, and is used for removing metal in the form of chips. The actual cutting is performed by a replaceable tool, called a cutter, which is relatively small compared to the rest

of the machine. Machine tools are generally classified as all-purpose or machine-shop tools and single-purpose or mass-production-line tools. The former is the type which has enabled Canadian plants to tool up for war production; the latter is the machine which has made possible the turning out of billions of bullets, hundreds of thousands of shells, and countless thousands of other war supplies.

Prior to the war, Canada's machine tools industry was comparatively small. The inventory of metal-working machinery in 1940 showed that only about one-third of the machine tools required for war work were available. Some of these were from one to ten years old; others—and these were in the majority—had been used for from 10 to 50 years.

To increase Canadian production and to buy available tools from the United States, Citadel Merchandising Co. Limited, was incorporated in May, 1940. In August of the same year, a Machine Tools Controller was appointed to co-ordinate deliveries and allocate machines to where they were most urgently required.

The Machine Tools Controller was given the power to anticipate Canada's requirements regarding the purchasing of machine tools which might be required for future contracts. In 1941, cutting tools and gauges came under the jurisdiction of the Controller, who set up new capacities to manufacture them. At the same time, he prohibited the exportation of any cutting tools until Canada's requirements were satisfied. On November 14, 1941, another Crown company, Cutting Tools Limited, was formed to salvage and recondition worn-out cutting tools for use in war plants.

The Machine Tools Controller has been responsible for setting up some valuable machine tool capacity in Canada. These plants are now an asset to the country and will take care of the Dominion's requirements for the future. Meanwhile, the plants have supplied a substantial proportion of Canada's needs and, by the use of certain surplus capacity, substantial quantities of tools have been shipped to Great Britain, other parts of the Empire, the United States, and Russia.

At the suggestion of the Controller, a Crown company, known as Machinery Service Limited, was incorporated on December 22, 1941, to overhaul and rebuild used machine tools, and to recondition equipment for contractors engaged in the production of war supplies. It is manned largely by skilled tool makers released for the purpose from refugee internment camps.

Records are maintained of machine tools available for sale in Canada, and of existing orders. Machine tools may not be exported except under licence. This enables the Dominion government and its contractors, as well as Canadian industry in general, to have first call on the output of Canadian plants.

Citadel Merchandising Co. Limited

In the early stages of Canada's production of war armaments, one of the first requirements was 50,000 machine tools to be added as rapidly as possible to the 30,000 new and obsolete units of metal-working machinery already in operation. The task was given to Citadel Merchandising Co. Limited, owned by the Crown.

Canada's machine tool capacity, built up over a long period of years, was then lower for a country of this size than it would have been in normal times of peace. This, of course, was the result of years of depression which held replacements to a minimum.

The company had two sources of supply: The United States, which found itself in the position of being a supplier of machine tools to most of the world except enemy countries, and Canadian manufacturers, who were granted liberal credits in order to encourage them to expand their production facilities.

The problems of the company were essentially problems of procurement, and because the United States was the principal source of supply, representatives were sent to New York and to Washington to maintain contact with the United States administration. This move proved particularly advantageous when the United States entered the war and the question of priorities arose.

Canada's sources of supply were tapped to the maximum, and the following figures of machine tool

production show the growth of the Dominion's capacity during the past four years: 1939, $4 million; 1940, $15 million; 1941, $23 million; 1942, $22 million; 1943, approximately $20 million.

Since successful machine tools are the products of the experience and mechanical ingenuity of their makers, generally speaking it was the company's policy to encourage the expansion of existing Canadian facilities instead of creating new capacity.

When United States priorities became a factor of delay, the company was asked to act in an administrative capacity as agents of the Priorities Branch in all matters affecting priorities for all machine tools to be brought into Canada, whether these tools were for government account or otherwise.

The percentage of used tools bought since the creation of Citadel Merchandising Co. Limited has been small, but they were useful implements in the hands of both prime contractors and sub-contractors. They were placed largely on a rental basis. Although it was anticipated that a number of these used tools would be returned to the company, almost all of them are still in service.

Since the middle of 1942, when procurement problems relaxed to some extent, Citadel Merchandising Co. Limited has engaged actively in the work of transferring equipment among government contractors. This has been a part of a policy of co-ordinated purchasing, the object of which was to avoid the purchase of machines and equipment already available in the plants of contractors whose need of the machines and equipment had ceased. Actually, it has gone further than that, because the company, with its knowledge of where the tools are located, has in many instances been able to arrange substitutions, loans, or other forms of adjustment.

Cutting Tools and Gauges Limited

Gauges—In the development of the Canadian munitions program, gauges, which control and determine the dimensional factors of every type of munition, have been

of great significance in the creation of the precision manufacturing methods and skills necessary to the production of acceptable standardized stores.

The widespread distribution of munitions contracts has forced all manufacturers and machine tool operators to become acutely conscious of close tolerances, and consequently, has raised the standards of workmanship and of production from machine tools.

Interchangeability of components and uniformity of products demand control and inspection, and the standards of quality established for British munitions of war are recognized as being of the highest order to assure the proper and safe functioning of guns, ammunition, and instruments under varied conditions of service.

Early in the war, the supply of gauges in Canada was the responsibility of the British Supply Board. When the board ceased to exist, the Gauge Division of the Department of Munitions and Supply took over. Canada, at that time, was largely dependent on United States gauge plants, and specialized gauge shops in Canada were virtually non-existent.

Following a period of reorganization of gauge shops, the Gauge and Cutting Tool Production Branch of the Department was formed. It continued to administer gauge procurement until May 15, 1942, when its functions were assumed by Cutting Tools and Gauges Limited. The company is responsible for the purchase of all inspection gauges requisitioned by the Inspection Board of the United Kingdom and Canada, and the various divisions of the Department of National Defence. It exercises control over the allocation of all shop gauges required by various munitions contractors.

Cutting Tools—As the munitions program progressed, it became evident that a serious shortage of cutting tools would occur unless Canadian production of these items was substantially increased. A Deputy Machine Tools Controller, with wide experience in the cutting tools industry, was therefore appointed. Through the co-operation of the cutting tools industry in Canada,

which consisted of well organized firms with the skill and ability to expand production, capital assistance was supplied where necessary by the Crown both for plant equipment and extensions, and the volume of cutting tools production in Canada surged upward.

One of the functions of the Gauge and Cutting Tools Production Branch was to assist contractors in the effective utilization of cutting tools to increase output and preserve critical materials, and it was later decided to form a company to implement this plan. Cutting Tools Limited was incorporated on November 14, 1941, and proceeded to assemble a plant which was brought into production in June, 1942. Meantime the company name had been changed to Cutting Tools and Gauges Limited. The Reclaiming Division was operated with the assistance of a large armament plant until the consolidation of all company activities in May, 1943.

Organized to serve all users of milling cutters in the national war effort, the functions of the Reclaiming Division is to salvage worn-out, undersize, obsolete, or discarded cutters by using the process of re-gashing without annealing developed by a pioneer firm of the tool salvage industry in the United States.

Since plant operations began on June 1, 1942, Cutting Tools and Gauges Limited has reclaimed 120,000 cutting tools, and at present has approximately 7,000 to 8,000 cutting tools in process.

The expansion of the cutting tool industry in Canada has resulted in the creation of productive capacity for standard cutting tools which is ample for the present wartime demands, and a substantial surplus capacity for export in standard types. This extension of capacity reached a peak volume of sales in October, 1942, with a total of nearly $2 million for the month.

Machinery Service Limited

During the first two years of the war, while Canada was importing and manufacturing machine tools on an increasing scale, the Machine Tools Controller realized that existing facilities were inadequate for the overhaul

of used tools to supplement the supply of new tools to war plants. The time also was approaching when additional facilities would have to be provided for the overhaul of machine tools on production lines, tools that would require major repairs owing to the stress of continuous service.

The problem was one of obtaining the necessary skilled labor without diverting essential men from vital war industries, and it was decided to utilize the services of a number of skilled engineers, draftsmen, toolmakers, machinists, and machine toolfitters in Canadian refugee camps.

Machinery Service Limited was incorporated as a Crown company on December 22, 1941, to overhaul and rebuild used machine tools which pass through the warehouse of Citadel Merchandising Co. Limited, and to recondition equipment for contractors engaged in the production of war supplies.

In the early part of 1942, a plant was rented in Montreal as a site for the new company. This site was later acquired outright. Part of the building was cleared of machinery, and the first group of men started work on January 31, 1942. The following departments were set up: Dismantling and erecting shop; machine shop; plating plant; woodworking and pattern shop; and drafting and engineering department. The work progressed rapidly, and the plant now is handling every type of machine tool from small bench lathes to the heaviest machinery.

The Tool Designing Division, organized in the early stages, has been disbanded as unnecessary under present circumstances.

Production of Machinery Service Limited has increased to a point where the company is now able to meet the major requirements of Canada's war industries for the overhaul and repair of machine tools.

METALS

ALTHOUGH Canada possesses only 1/188th of the world's population, it now ranks first among the nations as an exporter of base metals. Since the war began, excepting gold, the exports of non-ferrous metals and minerals and their products have risen in value from less than $213 million in 1939 to nearly $395 million in 1943.

This country is the greatest producer of nickel, asbestos, platinum, and radium, the second greatest producer of gold, aluminum, mercury and molybdenum, the third greatest producer of copper, zinc, lead, silver and arsenic, and the fourth greatest producer of magnesium. In terms of the Allied war effort, and excluding U.S.S.R. production, Canada is contributing 94 per cent of the combined nickel output of the United Nations;

20 per cent of the zinc output; 10 per cent of the copper output; 17 per cent of the lead output; 75 per cent of the asbestos output; and 32 per cent of the aluminum output.

With the expansion of the aluminum industry to a peak more than six times greater than that of pre-war days, with the development of facilities for producing magnesium from dolomite, with the extension of operations at the large base metal mines, with the revival of old mines, the expansion of existing mines, and the exploitation of new properties, including marginal and sub-marginal deposits, the past two years have ranked as the greatest in Canada's mining and metallurgical history.

To make the expansion possible an average of about 65,000 non-ferrous mine, smelter, and refinery workers, including those employed in gold production, were on the payroll in 1943, as against an average of 58,043 in 1939. A labor shortage has existed and the production of gold has dropped drastically to provide men for the armed services, base metal production, and other war programs.

Definite records of the annual value of metal and mineral production go back only to 1886. In that year the value of all mineral products was $10,221,255, or $2.23 per capita. In 1939 the total value of the country's mineral production was $474,602,059, or $41.94 per person. Despite the sharp drop in gold production the 1943 total was an estimated $524,426,850, or $44.40 per person.

Thanks to the skill and enterprise of her mining men, and thanks also to the stimulation provided by government assistance, the Dominion has fulfilled her obligations in metals and minerals to both the United Kingdom and the United States, and in addition has provided for her own essential needs. Because ocean losses dropped during 1943, and because of the success of efforts to provide new sources of production and increased production from known sources, the supply of certain strategic metals and minerals—aluminum, nickel, chrome

ore, magnesium, graphite, cobalt, mica, mercury, copper, tungsten, and molybdenum—is keeping up with essential demands.

In greater or lesser volume the nation has been producing aluminum, asbestos, antimony, arsenic, bismuth, copper, chromite, cobalt, cadmium, feldspar, fluorspar, gold, graphite, gypsum, iron, lead, magnesium, mercury, molybdenum, mica, nickel, pyrites, platinum, radium, sulphur, silver, selenium, silica, tin, tungsten, tellurium, talc, and zinc. A toll has already been taken of known ore reserves, but prospecting is being encouraged. Marginal and sub-economic properties have been tapped, and Dominion and provincial departments of Mines and Resources have fully co-operated with the Metals Control in this regard.

But the most amazing achievements have been in the production of the light metals, magnesium, and aluminum. The output of aluminum in Canada is not new, but its rapid expansion has rivalled that of any industry anywhere in the world. The Dominion's production is now roughly equivalent to the total world output in 1937.

The following tabulation shows the production in Canada of certain metals and minerals in 1939 and in 1943:

PRODUCTION OF SELECTED METALS AND MINERALS IN CANADA

(in 1,000 pounds)

	1939	1943*
Aluminum	165,000	985,300
Asbestos	728,000	884,000
Chrome ore	......	60,100
Copper (all forms)	605,800	589,400
Fluospar	480	22,900
Lead (all forms)	380,200	459,600
Magnesium	......	7,120
Mercury	440	1,690
Mica	2,140	2,410
Molybdenum	......	500
Nickel	226,100	287,600
Tin	......	780
Tungsten	......	840
Zinc	394,400	607,000

* Estimated. (In the copper, lead and zinc figures allowance has been made for estimated smelter losses in treating concentrates).

When the vast expansion of Canadian industries began after the fall of France, this country found itself in seriously short supply of many of the non-ferrous metals. To meet this grave situation, an order-in-council established the Metals Control on July 15, 1940 and gave the new Controller powers to regulate the supply, distribution and use of non-ferrous metals, and industrial minerals. Later, when even more serious shortages arose, a second order-in-council, on June 19, 1942, greatly broadened the Controller's powers.

One of the most notable achievements has been the substitution of less scarce metals for those in shortest supply. For example, silver is being used very largely in solders and brazing alloys to replace tin. Manganese bronze and lower-tin bronzes are being used instead of pre-war, high-tin bronzes for industrial castings, and a tin-free bronze has been developed and used for gear manufacture.

Shortly after taking office in 1940, the Controller restricted the domestic use of aluminum, nickel, zinc, magnesium, tin, cadmium, copper, and brass. All these controls were later tightened.

In the fall of 1940 it was ordered that the export of all non-ferrous metals and common metal alloys, whether in ingot, semi-fabricated or scrap form, as well as all industrial minerals, would require a permit approved by the Metals Controller. Exports have been carefully scrutinized and applications for non-essential use have been refused or reduced.

Because of rising war demands, the supply position of most non-ferrous metals showed no improvement until the latter half of 1943. Even essential civilian uses have been curtailed, and the shortages of some of the most important non-ferrous metals are likely to continue until the war is over.

The following table shows in a general way how five of the basic non-ferrous metals are now being used in Canada:

METAL	Direct War Consumption	Indirect War Consumption	Essential Civilian Consumption
Primary aluminum	96%	3%	1%
Refined copper	96%	3%	1%
Refined nickel	90%	8%	2%
Tin	.... 60%		40%
Refined zinc	87%	6%	7%

In every instance the war needs of the United Kingdom and the United States have been given priority in the matter of exports. The export of non-ferrous metal scrap is prohibited unless the scrap cannot be treated or is not needed for war production in Canada.

The Associate Metals Controller and the Power Controller represent Canada on the Materials Co-ordinating Committee of the United States and Canada, which handles problems relating to the supply of war materials between the two countries. Through this Committee, the Metals Control has a liaison with the various agencies of the United States government, such as the War Production Board, and the Metals Reserve Company. All war-purpose transactions between the two governments are executed by a Crown company, War Supplies Limited, acting for Canada, and by agencies such as the Metals Reserve Company, acting for the United States.

To assist the Controller and his Deputy, a staff of engineers, geologists, and consultants handles the administration of the Control under two operating divisions. One, the Development Division, regulates existing and projected metal and mineral production; the other, the Allocation and Conservation Division, is responsible for finding substitutes for critical metals and for allocating all available supplies whether from private or from government-financed producers.

Aluminum

The aluminum industry in Canada provides what is possibly the most spectacular story of wartime expansion in any industry in any country.

In 1938, the last full year of peace, the total production of aluminum in Canada was not quite 143 million pounds. In 1943, the industry turned out 985 million pounds.

The combined exports to the United Kingdom and the United States in 1938 were about 70 million pounds. Last year, after providing for all domestic war production, more than 444 million pounds were exported to Britain and 405 million pounds were sold to the United States.

Established at Shawinigan Falls before the Boer War, the Aluminum Company of Canada supplied the trivial Canadian needs of that war and of the first world war. Today, this same company operates a number of smelters in various localities among which is the largest in the world.

The principal requirements for the making of aluminum in Canada are bauxite from the tropics of South America, cryolite from Greenland, acid-grade fluorspar from Newfoundland and the United States, and electric power from the rivers of Quebec. At present about one-quarter of all the power consumed in Canada is used in this one industry, and the industry itself has been responsible for the development of much of the power it consumes.

Back in 1899 and the early 1900's long-term contracts signed by the Aluminum Company of Canada, helped to create what is now a vast power network centering in the St. Maurice Valley in Quebec Province. Less than two decades ago, the aluminum development was largely responsible for a hydro-electric plant at Ile Maligne which, with its installed capacity of 540,000 horsepower, was for a time one of the largest single sources of power in the world. A little over 13 years ago the 260,000-horsepower development at Chute à Caron was brought into operation. Until shortly before the present war, most of the capacity of this latter plant was surplus, and used for industrial steam production. Thus a reserve of a quarter of a million horsepower was available for increased aluminum production when the rumbling of this new war was first heard.

The war was not very old before this reserve power was put into active use. But the insatiable demand for more aluminum for aircraft, and for thousands of other

war purposes, made new power developments imperative. These new developments, known as Shipshaw, in themselves provide an amazing story of Canadian achievement (See Power Control).

Aluminum production over the past five years has been as follows:

1939	163,900,000 pounds
1940	215,000,000 pounds
1941	424,600,000 pounds
1942	671,700,000 pounds
1943	985,300,000 pounds

The demand for aluminum was so enormous—20,000 pounds are required for one large bomber—that beginning in August, 1940, the Control found it necessary to limit its use. The manufacturers of aluminum cooking utensils, and aluminum foil were advised that the supplies of primary aluminum would not be available for making those items. The use of aluminum for electrical conductors was restricted.

Under the authority of the Metals Controller, the Aluminum Company of Canada was authorized to fill war orders for primary metal, if a war order number were given. All other orders were referred to the Control, which either approved or rejected them.

In July, 1941, the curtailment restrictions were extended to secondary and scrap aluminum, and by the end of 1942, civilian consumption of primary aluminum in this country had been reduced to less than one fifteenth of one per cent of total Canadian production.

The imports and exports of aluminum were placed under the direction of the Metals Control.

In March, 1943, the Control issued three formal orders; two of which restricted the use of bauxite, alumina and cryolite, and the third curtailed transactions in and uses of aluminum. However, with the completion of Shipshaw, later in the same year, the shortage began to ease somewhat and restrictions on the use of secondary aluminum were removed. The consumption of primary aluminum continued to be closely supervised.

Antimony

A by-product of lead and zinc smelting, antimony is used in various alloys, chiefly with lead, and is essential for many purposes in war materials. The Canadian production of antimony in the first three years of the war was sufficient for domestic requirements, with a substantial amount available for export to the United Kingdom. In 1943, production lessened as a result of labor shortages and a drop in lead and zinc output, so that part of the Canadian requirements had to be imported from the United States, necessitating the cessation of exports to the United Kingdom.

Arsenic

The production of refined white arsenic in Canada is secured from the refining of gold-bearing ores. Approximately four-fifths of the present output goes to the United Kingdom for various war uses. At the same time this country imports from the United States most of its requirements for insecticides and weed killers.

Refined white arsenic is employed in the glass making industry. It is used also as a compound of many commercial chemicals.

Canada has one refinery, producing refined white arsenic, which secures its raw materials in the form of concentrates from two Quebec mines. One of these mines, in 1943, developed a wet process of producing refined arsenic from its own crude and, as a result, this material has become available for export to the United Kingdom.

Asbestos

Canada is the world's largest producer of asbestos, yet the domestic consumption is less than five per cent of the total output. About 75 per cent of the United Nations' requirements are being supplied by this country with the balance chiefly from South Africa. The major part of the exports go to the United States, but substantial quantities are shipped to Britain. In 1943 there was a shortage of spinning grades, chiefly used for essential war requirements, but this problem was being

met by strict conservation, with substitutions of lower grades being made wherever possible. A rigid control over exports to neutral nations is being exercised. According to an estimate of the industry itself, more than 80 per cent of the Canadian production is being used for direct war purposes.

Asbestos is an essential in making clothing for fire-fighting, for covering steam pipes and for the countless industrial processes which involve heat and the danger of fire. As an industrial component it is important in the manufacture of brake linings for automotive equipment.

Bismuth

Bismuth is produced in Canada as a by-product in the smelting and refining of lead. The output is sufficient for domestic requirements and some is being exported to the United Kingdom.

In the manufacture of tin-free solders, as well as in other alloys, bismuth is an important war metal. Salts of bismuth are used in various pharmaceuticals.

Cadmium

The over-all supply of cadmium, a strategic metal, is insufficient to satisfy all the Allied demands for essential war purposes. Cadmium is in extensive demand as an electro-plated coating to protect other metals from rust and corrosion, particularly critical aircraft parts.

Cadmium is produced in Canada, as a by-product, by two zinc operators, and thus the output depends on the amount of zinc produced. Domestic cadmium output has always been substantially greater than Canadian requirements, and earlier in the war relatively large surpluses were available for export to the United Kingdom and Russia. However, since 1942, the output has been decreasing while the demand has increased, thus lessening the amount available for export. It has been necessary to prevent the use of cadmium where a substitute would give satisfactory results.

The use of cadmium was first restricted in Canada on June 1, 1942, when an order prohibited anyone from acquiring the metal except by permit. On December 23, 1942, another order further restricted the use of cadmium for electroplating, even for certain war purposes.

Chrome Ore

Full relief from the shortage of chrome ore, as it affected war production, was achieved during 1943.

On May 29, 1943, the Chromereine project at Black Lake, Quebec, was officially opened. A project of the government-owned Wartime Metals Corporation, the mine is now producing and milling 600 tons of ore a day. In addition, the company mill has treated customs ores from other properties in the area. Another property in the Eastern Townships of Quebec is also turning out a substantial output under the direction of the Department of Mines and Resources. The principal sources of chrome ore prior to the war were South Africa, the Philippines, New Caledonia, India and Turkey. The Pacific war cut off Philippine supplies entirely and at present South Africa is the major source. Chrome is used largely in the production of ferro-alloys and basic refractories and is important in essential war needs for alloying in gun steel, armor plate and stainless steel.

Cobalt

In the early part of the war arrangements were made between the British government and the one large Canadian cobalt refinery to increase the output by the use of by-product cobalt residues of copper refining operations in Africa. At the same time a new refining plant was built in England under the control of the United Kingdom for similar production, and another unit of comparable type was installed in the United States by private interests.

In order to stimulate Canadian production of cobalt to provide a reserve for emergencies, a contract was arranged between the Metals Reserve Company, the United States metal buying agency, and War Supplies Limited, acting for the Canadian government, which in turn appointed Deloro Smelting and Refining Company Limited, as buying agents for cobalt-bearing ores mined

in the old camp at Cobalt, Ontario. The producers were advised that all their output of cobalt concentrates up to a total of 7,000 tons would be purchased at premium price and stockpiled for the account of the Metals Reserve Company. On this contract slightly more than 3,000 tons were delivered between April 1, 1942, and February 22, 1944; the contract was cancelled early in 1944, when the period of emergency had passed.

Pure cobalt is a silvery whitish metal resembling nickel, and as an oxide it is an ingredient of the brilliant blue pigment named after the metal. In combination with chromium and tungsten, it is used for high-speed alloys and special tool steels.

Copper, Brass and Bronze

At the beginning of 1944, the copper available to the United Nations was still not considered to be in excess supply to meet target production programs, and the Canadian demand appeared likely to rise. This country ranks third in world output and second in Allied output of this important metal.

Canadian production of refined copper exceeds Canadian needs but because the Allied demand is so great, this country has imposed many restrictions on civilian uses. After war and essential civilian requirements have been provided, the refined copper surplus is exported to the United Kingdom and surplus concentrates to the United States. The production of brass and bronze, in which copper is the chief constituent, has risen by some 1000 per cent since the outbreak of war.

It is estimated that less than one per cent of the copper mined in Canada is now being used for purposes which are not directly or indirectly associated with the war program.

Of the wrought copper and brass produced in Canada some 98 per cent is being used for the manufacture in this country of shells, warplanes, ships, guns, tanks, and other war supplies. Approximately two per cent is divided between exports and essential civilian uses. Of the copper wire being manufactured in Canada, some

47 per cent is being used for direct war purposes in this country, 50 per cent for essential civilian purposes, two per cent for exports, and one per cent for other purposes. The civilian demand for copper wire rose sharply at the beginning of January, 1943, after a severe storm did extensive damage to communication lines in Quebec and Ontario.

On behalf of the Metals Reserve Company, the U.S. government metal procurement agency, the Metals Control arranged, early in 1943, for the development of marginal and sub-marginal properties in Canada.

By the end of 1943, the shortage had eased somewhat, but prospects for 1944 indicate that the demand will rise again. At the end of 1943, Canada had sufficient copper for all war and essential civilian requirements including public utilities, but in view of the over-all Allied shortage insufficient was available to permit non-essential uses.

The control over primary copper production and distribution was instituted by the government shortly after the beginning of the war. The first control over manufactured forms was through the facilities of the principal fabricators whereby their customers were placed on a quota basis. As the situation became more critical, formal orders were issued defining very closely the uses which could be permitted without special approval. These orders resulted in very drastic curtailments of non-war uses.

Production of refined copper during the past five years was:

1939	463,200,000 pounds
1940	523,800,000 pounds
1941	556,400,000 pounds
1942	541,200,000 pounds
1943	508,400,000 pounds

Fluorspar

Because the production of fluorspar in the United States was greatly increased in 1943 and certain economies were instituted, the supply of this mineral became more plentiful and sufficient was available for all war purposes.

Although six Canadian properties were in actual production during the first half of 1943, the bulk of the Canadian supply still came from the United States and other sources. The six properties include two at Madoc, Ontario, which were in production in 1942. Of the other four, three are new Madoc properties and one is in Cape Breton.

Fluorspar is used in making aluminum, steel, glass and certain chemicals.

Graphite

The occupation of Madagascar eased the Allied shortage of graphite, and supplies are now being shipped from that island. Graphite is used for crucibles in which steel and other metals are melted. The production of graphite crucibles in Canada has been negligible, and this country has depended mainly on the specialized plants in England and the United States for its relatively small needs.

Canadian graphite deposits have been worked at intermittent periods in the past, but when this country entered the war it had no production of crucible grade, although it has a supply of graphite suitable for other purposes such as foundry facings, lubricants, and sundries.

Iron Pyrites

Iron pyrites is a common by-product of the concentration of copper and zinc ores and until late in 1943 it was obtained mainly from the Noranda and Aldermac mines in northwestern Quebec. With the shut-down of Aldermac, production at that mine ceased, but increased production was obtained from other mines. Part of the output is exported, the remainder being used in the manufacture of sulphuric acid or in making sulphur dioxide by the Freeman process for chemical wood pulp treatment.

Lead

Although Canada ranks as the third of the nations in the production of lead, she normally does not consume more than a fraction of the output. The difference during

the war years is being made available for essential United Kingdom and Russian requirements. However, since the outset of the war, Canada's consumption of lead has risen sharply because of war demands and the use of the metal as a substitute for more critical materials.

On the other hand, production of refined lead has likewise increased from 191,300 short tons in 1939 to 224,500 short tons in 1943. Peak production was reached in 1942 but labor shortages in the base metal mines were responsible for a slight reduction in 1943.

The use of lead in Canada has not been restricted, but the flow of the metal was governed by orders of the Metals Control so that a constant check could be made on all consumption with means to provide restrictive machinery should a crisis have arisen. On September 29, 1943, an order virtually lifted the mandatory control over lead with the exception that no person may acquire or accept delivery of any lead if by so doing he would have a quantity on hand in excess of 60 days' normal supply. All exports are closely controlled.

Magnesium

At the end of 1943, Canada was producing more than ten tons of magnesium per day and after supplying all her own needs is able to export the major part of this tonnage to the Allied nations. Until the $3 million project of the government-owned Dominion Magnesium Limited at Haley, Ontario, turned out its first crown of magnesium in the summer of 1942, potential millions of tons were locked in brucitic limestone and dolomite ores, but not one pound of commercial magnesium was available in Canada that had not been imported.

To extract magnesium oxide from those plentiful ores would have been easy enough, but the problem that faced the metallurgist was how to remove the oxygen from the oxide quickly and cheaply, without causing an explosion. Thanks to the foresight of Lieutenant-General A. G. L. McNaughton, until recently commander of the Canadian Army, then president of the National Research Council, a young McGill graduate, Dr. Lloyd M. Pidgeon, a native of Markham, Ontario, was assigned to tackle

the problem in the Council's laboratories in 1937. By November, 1940, he had found a laboratory answer and within another year had proved the process commercially so that a domestic industry could be established.

Only a few miles from the Ottawa River and not far from Renfrew, the site of the Dominion Magnesium plant is a wilderness of sand and rock, pine trees, and second-growth birch. Chosen not because it was the only source of dolomite, but because the outcropping was close to available power, the site had the advantage of being conveniently near transcontinental railway lines and not too far from other war industries.

On a sunshiny, sub-zero day in the first week of February, 1942, workmen with pneumatic drills broke through twelve inches of frozen topsoil to turn the first sod for the plant. Fifteen days later the first concrete was poured, and within a little more than six months enough of the plant was constructed to begin operations with brucitic limestone brought in from a Quebec property. With no ceremony, no headlines, the first crown of magnesium left the reduction furnace on August 15. Less than three months later, on November 9, the crushing and calcining plants were nearing completion, and the company swung over to the use of dolomite ore from its own backyard. By December 15, 1942, construction work was completed and the daily output was approaching its peak.

In the production of magnesium, ferro-silicon is used as a reducing agent. It is estimated that from one ton of ferro-silicon and 10 tons of dolomite, one ton of magnesium ingots can be produced.

Magnesium is a metal so weak in its pure state that a small boy could bend a half-inch bar, yet so tough as an alloy that it will stand the shock of landing a 30-ton warplane. It is so effective as an incendiary ingredient that it will burn up many a German city, yet so inert as a solid that a 3,500-degree blow torch could be applied to it and it would not burn.

To the chemist it is a metallic element which, in its natural state as an oxide associated with other elements,

is almost as common as iron, and in its artificially pure state was, until a short time ago, rarer than silver.

As far as North America is concerned, Canada has pioneered in its production. First commercial output on this continent was from United States raw materials processed by Shawinigan Electro Metals Company from 1915 to 1919 in Shawinigan Falls, Quebec. First production from Canadian materials, and first use of the new, more rapid and safer Pidgeon process, was at the Dominion Magnesium plant. Already the United States government has utilized the same process or other ferrosilicon methods in plants costing about $50 million.

When war broke out the production of magnesium on this continent was insignificant. By the end of 1943, the United States and Canadian production total far exceeded that of the Axis and was sufficient to meet all essential war requirements.

Until the output from Haley began to flow, the North American supply was coming from the treatment of sea water or subterranean brine in the United States. Now that more or less ample supplies are assured, war uses of the metal are almost certain to multiply. Meanwhile, its chief use is in aircraft alloys, metals tough enough to stand terrific flying strains and stresses, yet light enough to add hundreds of miles to the effective range of a bomber or fighter. Every bit as important to the airman, is the use of magnesium as an ingredient of parachute flares so brilliant that they will light up a large target area thousands of feet below the aircraft. In addition, magnesium is used in night bombs, in certain shells, and in other pyrotechnics. Magnesium castings for industrial purposes are being put to increased use.

Dominion Magnesium Limited is a private concern, operating without profit or fee, financed by the federal government, and under the supervision of Wartime Metals Corporation, a Crown Company (See Wartime Metals Corporation, page 232).

On March 30, 1943, an order provided that no person might acquire magnesium except by permit. The order also called for the careful segregation and proper

identification of magnesium scrap by producers. Before the end of 1943 these restrictions were rescinded so far as they concerned domestically produced magnesium, but all imports and exports are by licence approved by the Controller. The freely permitted use of Canadian magnesium is expected to benefit metallurgists to the extent that development and research may find new adaptations of the metal.

Manganese

All manganese metal and alloys produced in Canada are under strict allocation by the Metals Controller. In the past the chief sources for Canadian requirements of ore have been Takoradi on the Gold Coast of Africa, Brazil, Cuba, the U.S.S.R., Baluchistan, and the east coast of India. At the end of 1942 the chief sources were New Caledonia and the Gold Coast.

Canada's known deposits are limited in size and unless new discoveries are made, this country must continue to depend on outside sources.

Manganese is necessary in the production of the steel used in ships, guns, tanks, and hundreds of other tools of war.

Mercury

Production of mercury in Canada has been an outstanding phase of this country's war effort. In peacetime, Canada was entirely dependent on imports from Spain, then the most important producing country in the world. Because of U-boat sinkings, the Nazi domination of Europe, and the greatly-increased demands, insufficient mercury was available to the United Nations. To meet this situation, three important deposits were opened up in British Columbia, and Canada now stands second among the nations as a mercury producer. The Canadian output should be of importance in post-war markets but, in the meantime, Canada is supplying large quantities for the needs of the United Kingdom and the United States, and for certain of the requirements of other countries in the Empire.

Mica

Although the Allied occupation of Madagascar eased somewhat the shortage of phlogopite-grade mica, the production of muscovite grade in Ontario and Quebec is regarded as an important contribution to the war effort. The output from the Purdy mine at Mattawa, Ontario, largest new discovery of its kind in North America, was increased during the first half of 1943. This mine began producing during the summer of 1942.

Late in 1943, Purdy Mines Ltd. opened a large trimming plant at North Bay employing 200 workers.

On February 23, 1943, it was announced that strategic quality muscovite mica would thereafter be purchased in Canada at higher than the U.S. ceiling price. The official purchasing agency in Canada is the Colonial Mica Company, a United States government-owned company, operating an office in North Bay, Ontario.

Molybdenum

Molybdenum is being produced in substantial quantities in Canada, whereas before the war no such production existed.

Most of the pre-war requirements were imported from the United States, which produced approximately 90 per cent of the world's supply. Wartime demands and the shortages of other alloy metals, such as nickel, vanadium and chrome, placed great strains on the molybdenum supply available to the United Nations. As a result molybdenum became one of the first metals in short supply.

The encouragement and stimulus given to the Canadian mining industry by the Metals Control led to the discovery and development of two important molybdenum deposits. During the first six months of 1943, one of these properties went into production under the operational direction of Wartime Metals Corporation. Later in 1943, the other property went into comparatively large scale production under the ownership and management of Dome Mines Limited, a gold mining company.

Production from these properties enabled the Metals Control to build up a substantial stockpile of molybdenum concentrates sufficient, together with the current production, to meet all Canadian requirements, and for the first time in Canadian history this country is self-sufficient in this metal.

Molybdenum products such as wire, rod and sheet continue in short supply in Canada although adequate supplies of molybdenum concentrates, oxides and ferro-alloys are available. Wire, rod and sheet are essential in the manufacture of radio and radar equipment but are not produced in Canada and must be imported from the United States.

Nickel

Nickel production during 1943 was 25 per cent greater than at the beginning of the war. Canada is providing 94 per cent of the nickel available to the Allies. Most of the remaining output comes from New Caledonia, and some small quantities in oxide form are being shipped from new properties in Cuba.

The International Nickel Company of Canada and Falconbridge Nickel Company are the sole producers of primary nickel in Canada. At both mines expansion work took place in 1942, and by the end of that year peak production had been reached.

After the outbreak of war, and prior to any official action, International Nickel Company, under the advice of the Metals Controller, took steps to exercise a measure of control over domestic consumption.

The Controller later instructed the companies to restrict the use of nickel as far as possible to war industries. Arrangements were made to record and control the priority allocation of nickel and nickel-bearing alloys. Nickel for electroplating purposes was reduced to 50 per cent of the 1940 and 1941 consumption.

Consumption of nickel for war and essential civilian purposes has left only a small amount for other uses. In 1940 the direct and indirect war use was 60 per cent, in 1941 it was 85 per cent, and in 1943 it was 98 per cent.

The silverware manufacturers, as an example, agreed to reduce the nickel content of nickel-silver from 18-21 per cent to 12 per cent on September 1, 1941, and by the spring of 1942, they were getting no nickel at all. The greatest civilian saving, however, was effected by the stopping of passenger car and civilian truck manufacture. Next in importance was the saving made possible by revisions in nickel alloy specifications.

All nickel is under strict allocation, but small quantities are being released for essential industrial purposes.

Production of nickel in Canada during the past five years has been as follows:

1939	113,000 tons
1940	122,800 tons
1941	141,100 tons
1942	142,800 tons
1943	143,800 tons

Platinum

Canada, the world's greatest producer, uses only a very small percentage of its platinum output. As a by-product of nickel refining, it is shipped to the United States for refining and brought back as pure metal. The re-importation figures have risen rapidly since the war began.

An order of the Metals Control, effective January 15, 1942, restricted the use of platinum and the platinum group metals, and licensed certain dealers to handle such metals. The object of the order was to conserve supplies, and to prevent any possibility that the metals might leave the country and get into enemy hands.

Radium

Before the war, a Belgian refinery turned out most of the world's commercial radium supply from ore mined in the Belgian Congo, but a Canadian industry was being built up from domestic deposits of pitchblende and a refinery had been established to treat the concentrates. Today, Canada ranks first in radium production and the refining plant at Port Hope, Ontario, treating high-grade

domestic pitchblende from the Great Bear Lake area of the Northwest Territories, is working full-time on essential and war needs.

Because of increased war demands for radium, the government has purchased Eldorado Mining and Refining Limited, which owned the Port Hope refinery, and is operating both the mine and the refinery as a Crown company.

Under bombing attacks, the large X-ray tubes in hospitals are easily damaged and, for this reason, the hospitals have been returning to the use of radium. Radium salts are finding an increased use in the field of radiography for inspection of large steel castings. They are also an essential component of luminous paints for gun sights, aernonautical instruments and other military equipment.

Silica

In the form of crude rock enough silica is obtained in Canada to supply the substantial needs of the producers of silicon and ferro-silicon.

Silica also comes in two other forms, as sand and as ground silica, silex, or flint. The first of these two forms is used for making glass and abrasives, and for steel foundry operations. The second also is used in foundry work, for ceramics, and for sundry other purposes. The production in Canada of these two forms is insufficient for domestic needs, and the balance must be imported from the United States.

Generally speaking, silica is in adequate supply.

Silver

Traditionally regarded as a precious metal and as a medium of exchange, silver has taken its place as a war metal. Eminently satisfactory as a substitute for tin in solders and for use in brazing alloys, silver has found wide use in war industry. As one of the largest silver producing countries in the world, Canada has available adequate supplies of the metal for all uses including coinage.

During the first half of 1943, owing to price differentials between Canada and the United States, the primary producers of fine silver agreed to pool their export and domestic sales so that the monetary return per ounce could be averaged and domestic requirements equitably met.

The Metals Control ordered that after September 30, 1942, no person was to acquire or sell more than 500 troy ounces of fine silver or more than 500 troy ounces of silver contained in an alloy, except by permit. The movement of silver brazing alloys, containing not more than 50 per cent silver, was unaffected by the order.

Tin

In peacetime, three-quarters of the world's supply of tin came from Malaya and the Netherlands East Indies. Bolivia was next in importance, and some also came from the Belgian Congo and Nigeria.

When Japan over-ran the South Pacific area that source of supply was cut off, and the United Nations were deprived of 75 per cent of their tin imports. Shipments from the other sources run the risk of enemy action at sea.

Canada produces no tin ores, although she now has a small production of refined tin as a by-product from certain lead-zinc ores.

In 1940 the Canadian government began purchasing tin for stockpile, and arranged with industry to buy all stocks on hand with the exception of material in the hands of approved consumers using the metal for war and essential purposes.

As a result of conservation steps taken in Canada, the United States and the United Kingdom, the Allied nations now have sufficient tin reserves for essential requirements, if shipments can be maintained from Bolivia, the Belgian Congo and Nigeria.

Tungsten

Tungsten is used primarily in the production of high-speed steels, and is thus employed in almost every phase

of war manufacture. It is also used for the filaments of electric lamps. It is an essential in making components for radar and for radio tubes. In powder form it goes into the manufacture of cemented tungsten carbides.

Some tungsten is produced in Portugal, South America, the United States and Mexico, and lesser amounts in Australia and New Zealand, but the principal pre-war sources were China and Malaya. The war in the Pacific cut off these latter sources and production on the North American continent had to be greatly stimulated.

Soon after taking office, the Controller, in November, 1940, set up a government stockpile of ferro-tungsten.

Quantities of scheelite, the tungsten ore, were found in association with the ores of certain gold mines in Canada, and a small production was secured from these sources. One of the most important discoveries yet made on this continent is the Emerald deposit at Salmo in British Columbia, exploited for the Metals Control by Wartime Metals Corporation at a substantial production rate. When sufficient became available for essential purposes and a stockpile of concentrates had been built up, the mine suspended operations.

Canadian scheelite ore in the form of concentrates rating 60 per cent WO_3 or better was shipped direct to a steel plant in Ontario. Concentrates of a lower grade were shipped to the United States for recovery.

When the shortage was at its worst, new alloys were developed for economy in the use of tungsten.

While adequate supplies of tungsten, in the form of concentrates and as a ferro-alloy, are available in Canada, tungsten in fabricated forms, such as wire, rod and sheet, continues in short supply; such requirements must be imported from the United States.

Zinc

The western hemisphere is the chief source of zinc for the Allied nations. It produces approximately 1.2 million tons of zinc per year, most of which is smelted

in the United States. Canada is the world's third largest producer. The wartime output is directed into munitions making in this country, into essential civilian manufacture, and into exports to the United Kingdom.

Although the Canadian output is greatly in excess of domestic requirements, strict curtailment of civilian consumption was undertaken to provide sufficient for Allied war production. In addition, zinc ore output on this continent was stepped up and new Canadian production was successfully encouraged. All of the Canadian metal output comes from two large producers of primary zinc. The new output was secured from sub-marginal properties in Quebec, Ontario, Manitoba and British Columbia and is in the form of concentrates which are exported to the United States.

Production reached a peak in mid-1943, and by the end of that year it was considered likely that sufficient would be available to permit the closing down of the uneconomic sub-marginal properties and the transfer of badly needed manpower to essential mines.

The supply position of zinc metal has improved to such an extent that the lifting of some of the restrictions on civilian consumption has been possible.

Non-Ferrous Scrap and Ingot

The supply of non-ferrous metal scrap has been under close review by the Metals Control since its inception. Formalized administration began in April, 1942, and since then the movement of practically all types of scrap has been rigidly supervised. The collection of all non-ferrous scrap is encouraged and its economic distribution has required that it be sent, in order of priority and grade of material, to the primary metal fabricators, such as the rolling mills and extrusion plants, or to the secondary ingot manufacturers, where the use of scrap can be closely controlled and where maximum conservation of metal may be secured. In all respects, the scrap program has proved effective, supplying an important part of the metal requirements of war and essential industry.

The manufacture and movement of non-ferrous metal ingots is regulated by orders of the Metals Controller. The manufacture of all tin-containing ingots is kept to close specification limits, established by a non-ferrous castings advisory committee, composed of metallurgists of the Control and representatives of industry, the armed services and other governmental bodies. This procedure has ensured maximum tin conservation and satisfactory metal supply.

Wartime Metals Corporation

Wartime Metals Corporation was formed as a Crown company on March 17, 1942, to assist the government in meeting the demand for strategic and critical metals. The corporation functions as an operating unit of the Department of Munitions and Supply, working in collaboration with the Metals Controller to meet metal and mineral shortages as they may occur. Developments to date have included the exploitation of new or additional sources of magnesium, tungsten, molybdenum, chrome, copper, zinc, lead, vanadium, lava talc and corundum.

The first task assigned to the corporation after organization was the responsibility for the supervision and putting into operation of the government-owned magnesium project at Haley, Ontario, which, while under the private management of the Dominion Magnesium Limited, was financed by the Crown.

In certain instances, for the over-all requirements of the United Nations, the corporation undertakes the development of projects and operates them for the account of War Supplies Limited, which in turn deals with the Metals Reserve Company, the United States metal-buying agency, under arrangements concluded by the Metals Controller. In most cases these properties were not operating at the start of the war and were regarded only as high-cost potential producers.

The following projects have been operated for the account of the Metals Reserve Company:

1. **Kam Kotia Porcupine Mine**
   Northern Ontario—copper concentrates.

2. **Britannia Mining and Smelting Company**
British Columbia—copper concentrates.

3. **Granby Consolidated**
British Columbia—copper concentrates.

4. **Tyee (or Twin "J") Project**
British Columbia—copper and zinc concentrates.

5. **Tetreault Lead and Zinc**
Quebec—lead and zinc concentrates.

6. **Lake Geneva Mining Company**
Northwestern Ontario—lead and zinc concentrates.

7. **Kootenay-Florence Mining Company**
British Columbia—zinc and lead concentrates.

Activities of Wartime Metals Corporation on behalf of the Canadian government can be summarized as follows:

1. **Dominion Magnesium Limited**—The magnesium project at Haley, Ontario, came into full production in March, 1943. The output at the end of 1943 was more than 10 tons per day, and as improvements continue the rate will be increased. Production costs are dropping satisfactorily.

2. **Molybdenite Corporation of Canada**—The mining operation known as the LaCorne project in the Province of Quebec was taken over by Wartime Metals and, following further underground development, the mill on the property was re-constructed on a larger scale. Milling began in the spring of 1943, and is now at a rate of 200 tons a day. Substantial ore reserves have been developed.

3. **Chromereine**—This chrome project located in the Eastern Townships of Quebec went into operation on May 28, 1943. Initial milling rate was 345 tons of concentrates a day, which was levelled off to a daily average of 300 tons.

4. **Emerald Tungsten Mine**—Located in British Columbia, the Emerald property is one of the most outstanding tungsten deposits in North America. When only a prospect, it was taken over by the government and developed by Wartime Metals Corporation. Production of tungsten concentrates began in June, 1943, but, when the over-all Allied tungsten supply position eased, it was considered advisable to close down the property in September of that year pending a rise in the demand for tungsten.

5. **Corundum**—In conjunction with the Metals Controller, acting on behalf of the United States Office of Foreign Economic Administration, the corporation has undertaken an investigation of the old mill tailings at the shut-down corundum properties at Craigmont, Ontario, with the view to their development as a source of required optical abrasives.

6. **Lava Talc**—Development of a lava talc deposit, along the Alberta-British Columbia border in the national parks area, in the latter part of 1943, was instituted by the corporation at the request of the Metals Controller, acting in association with the United States Office of Foreign Economic Administration. Shipments from the property were expected in early 1944.

7. **Zenith Molybdenite Corporation**—An old molybdenum producer in eastern Ontario, the mine was re-opened and a substantial amount of development done, with disappointing results. After salvaging the small amount of high-grade ore available and a large part of the equipment, the property was closed.

8. **High Lake Molybdenite**—Diamond drilling of molybdenite showings in the Kenora district of northwestern Ontario proved unsuccessful.

9. **Vanadium**—Ash residues containing vanadium, secured from oil burning ships on both Canadian coasts, have been collected by Wartime Metals Corporation, for shipment to a commercial plant in the United States for the recovery of the vanadium content. Because the

residues were mostly secured from British ships, the Combined Raw Materials Board ruled that the United Kingdom should have first call on this source of vanadium, with the result that the Canadian supply has largely dried up, as most of the ash is now being collected at United Kingdom ports. Consequently, in the autumn of 1943, Wartime Metals Corporation ceased this operation.

10. Scrap Brass—On recommendations from the Metals Controller, Wartime Metals Corporation has acted as an agent for the acquisition and sale of secondary ingots for Canadian war industry. The ingots were manufactured by ingot makers to the specifications of the Controller and the corporation is holding the ingots for emergency requirements of Canadian industry.

OIL

THE late Earl Balfour is credited with saying that in the first world war the Allied Nations "floated to victory on a sea of oil." In this more widespread and more highly mechanized war, the need for oil is immeasurably greater.

Fortunately, the largest oil reserves are on the side of the democracies. Even with the temporary acquisition of large fields in the Orient, the Axis powers control less than six per cent of the world's potential annual capacity, while most of the remaining capacity is available to the Allies.

Yet paradoxically, the problem of oil is grave and the probable available supply of certain petroleum products will be decidedly worse before it is better. In 1941 and 1942, the bottleneck was transportation. Today, it is

prodigious demands outstripping dwindling supplies. The military demands, even before the opening of a second front are three times what they were in 1942. The wells are running dry faster than new wells can be discovered. The major Allied nations are finding it necessary to go farther and farther afield for their requirements.

For Canada this means less available oil from the United States and a greater dependence on heavier Venezuelan and Colombian crudes. For Canadians this means, on the one hand, a larger supply of asphalt and heavy fuel oil, and on the other hand, a poorer quality motor gasoline, and greater difficulty in maintaining adequate supplies of motor gasoline and light fuel oil and in keeping up the flow of sufficient aviation gasoline.

Like most of the larger oil-consuming countries in the world, Canada depends chiefly on outside sources of crude. Although she is second only to Trinidad among the British Empire producers and tenth among the oil producing nations of the world, the capacity of her wells is sufficient to supply only 15 per cent of the domestic demand. Apart from the United States and Russia, which accounted in 1939 for nearly three-quarters of both the world's production and consumption of petroleum, Canada's consumption was exceeded in that year only by the United Kingdom and Germany. Per capita consumption in this country is greater than in any other country except the United States, which leads the world by a very wide margin.

In 1938, the last full year of peace, Canada used 51 million barrels of crude oil. In 1943 she used approximately 61 million barrels, an increase of approximately 17 per cent. Here are some of the reasons for the increase:

1. Canada's Navy rose in strength from 15 ships before the war to more than 650 at the end of 1943. For these ships she needs many more millions of gallons of oil per year than she needed in 1938.

2. Canada's Army is for its size the most highly mechanized in the world. In one division, 15,000 men,

there are as many motorized units as there were in Canada's whole army in the field during the first world war; hence the need for more petroleum.

3. Canada had no Air Force in the first great war. Shortly thereafter she obtained a nucleus of an Air Force. In January, 1944, she had thousands of planes and each plane used five times as much gasoline as the old-type aircraft. At the R.C.A.F. airports in Canada about half a million gallons of gasoline have been usually used in a day.

4. Substantial quantities of petroleum are needed for making synthetic rubber.

5. Canada's industrial production, because of the war, is roughly three times what it was in 1938. Modern machinery is useless without oil. This demand runs into many millions of gallons per year.

The magnitude of the Canadian consumption can best be expressed in this way: If all the petroleum required by Canada were placed in standard 35-gallon barrels, a 1938 line-up along the equator would extend two-thirds of the distance around the world. The war-time increase would bridge the Pacific.

Yet this Canadian consumption is small by comparison with the total world output and small by world standards. The world production of crude oil in 1939, the last year for which statistics are available, totalled 2,077 million barrels or approximately 73 billion gallons. Of this total the United States produced 1,265 million barrels and the Union of Soviet Socialist Republics, 213 million barrels. The balance of 599 million barrels was produced as follows:

	(In Millions of Barrels)
Venezuela	206
Iran and Iraq	109
Netherlands East Indies	61.5
Rumania	46
Mexico	43
Colombia	22
Trinidad	19
Argentina	18
Peru	14
Canada	8
All Other Countries	52.5

As against this output, the world consumption in 1939 amounted to 1,230 million barrels in the United States, and 170 million barrels in the Union of Soviet Socialist Republics.

The remaining 620 million barrels were consumed as follows:

	(In Millions of Barrels)
United Kingdom	89
Germany	54
Canada	51
France	45
Argentina	31
Netherlands West Indies	23
Italy	22
Mexico	19
Australia	18
Rumania	15
Iran and Iraq	15
Netherlands East Indies	11
Venezuela	10
All Other Countries	217

Fortunately for Canada, her neighbors in the Americas have enjoyed a large proportion of the surplus oil production, and it has not been necessary to go beyond the Western Hemisphere for Canadian supplies.

Oil Refining

The function of an oil refinery is to convert crude oil into such finished products as aviation gasoline, motor gasoline, kerosene, and fuel oil.

The basic process in refining crude petroleum is that of distillation. Petroleum is a liquid comprising an almost infinite series of different molecular combinations of hydrogen and carbon, each combination having a different boiling point. The hydrocarbons which are predominantly hydrogen are both light in weight and low in boiling points, and the hydrocarbons which are predominantly carbon are heavier and have higher boiling points. Gasoline consists of the lighter hydrocarbon combinations and heavy bunker fuel and asphalt the heavier, with kerosene, tractor distillate, light fuel oils, and lubricating distillates ranging in between.

The refining process consists chiefly of the application of heat to crude oil so as to vaporize the lighter hydrocarbons and permit their segregation by selected boiling ranges upon condensation. Modern refineries

also use a process of destructive distillation which causes the molecular combinations of the hydrocarbons to alter upon the application of high temperatures and pressures. The straight distillation of crude oil by the application of heat alone is referred to as "skimming" or "topping," and the destructive distillation caused by the application of heat under pressure is referred to as "cracking."

In addition to "skimming" and "cracking," numerous other processes are employed for technical purposes, the chief of which is to remove impurities from the finished products. The chemistry of petroleum is a vast subject, and technical improvement in refining technology has been the development of processes which permit higher yields of gasoline to be obtained from a barrel of crude oil. The success achieved in this direction, and in greatly improving the quality of gasoline, is a fascinating story. Without these improvements modern civilian and military vehicles and aircraft would be useless, and the prodigious quantity of gasoline required could not be met from current crude oil production.

The principal products of refining are petroleum fuels such as gasoline, tractor distillate, kerosene, and light and heavy oils, although lubricating oils, asphalt and coke are of some importance.

Oil Industry in Canada

The petroleum industry in Canada embraces all operations including the search for, and production of crude oil and natural gasoline, as well as transportation, refining, distribution, and retailing.

In 1943, 36 refineries were operating in Canada and 315 companies were marketing petroleum products as producers, importers, jobbers and wholesalers. Of the more than 30,000 gasoline retail outlets approximately 4,000 were owned by oil companies and the balance were operated in conjunction with tourist camps, hotdog stands, rural general stores, hardware stores, garages, and other businesses. In addition, nearly 12,000 individual consumers operated their own gasoline storage and dispensing equipment.

About 90 per cent of the Canadian petroleum gallonage is handled either directly or indirectly by five major oil companies. The dealer outlets are supplied chiefly from about 3,000 bulk stations in the principal centres. About 33 per cent of these stations are in the eastern provinces, 59 per cent on the prairies, and 8 per cent in British Columbia. The prairie bulk stations for the most part are relatively small; whereas some of the eastern stations and marine terminals have large storage capacity for receiving deliveries by tankers and for storing during the closed navigation season. These marine terminals in eastern Canada, and on the Pacific coast, normally are supplied direct from the refineries by lake and coastal tankers, of which the oil companies operate approximately 40, in addition to numerous smaller craft, harbor lighters and barges. The lake vessels are used to supply part of Ontario and Montreal crude requirements from Toledo, Ohio. Of the 36 refineries, 11 are in the eastern provinces comprising one at Halifax, four at Montreal, four in and near Toronto (including one completed recently at Clarkson), one at Sarnia, and one at Petrolia. These 11 refineries process approximately 100,000 barrels of crude oil per day. The 22 refineries in the prairie provinces handle approximately 30,800 barrels per day and are located chiefly at Calgary, Moose Jaw, Brandon, and Winnipeg. The three refineries in British Columbia run a total of about 17,200 barrels per day. Of the total of 148,000 barrels per day run by all Canadian refineries, about 139,400 barrels per day are handled by the 16 plants operated by seven large oil companies. The remaining 19 independent refineries account for only 8,600 barrels or 6.2 per cent of the total. Canada's petroleum requirements are supplied largely from these refineries, which fortunately have sufficient capacity to meet the Canadian civilian and war requirements as well as those of Newfoundland. In 1942, the refineries produced 48 million barrels of petroleum fuels as compared with importations of 3.35 million. Of the importations, 1.187 million barrels were fuel oil, brought in mainly for ships' bunkers and railroads, and 1.533 million barrels were refined gasoline and other white products.

The total Canadian petroleum requirements have increased sharply since the outbreak of war. Exclusive of lubricating oils and greases, the annual requirements in barrels for the past six years have been:

Year	Crude Oil	Refinery Blending Stocks	Imported Fuels	Total
1937	40,786,399	1,934,953	2,254,503	44,975,855
1938	41,187,724	1,619,354	3,679,002	46,486,080
1939	44,599,033	1,108,645	3,937,454	49,645,132
1940	51,059,049	1,648,032	4,170,313	56,877,394
1941	56,288,803	2,074,485	2,955,012	61,318,300
1942	54,006,654	2,460,339	3,351,880	59,818,873

The refinery blending stocks referred to in the foregoing table comprise chiefly natural gasoline and aviation blending agents. Natural gasoline, sometimes known as casinghead, is a highly volatile gasoline extracted from natural gas and used by refiners to blend in varying degrees with gasoline manufactured from crude oil. It provides the desired quality of volatility in the finished motor gasoline. Approximately one-fourth of Canada's requirements of natural gasoline comes from natural gas in the Turner Valley, the balance being imported from the United States and South America.

Aviation blending agents are extremely high octane gasoline products, which are blended with aviation gasoline distilled from crude oil to produce high-octane aviation fuels. Until recently all these blending agents have been imported. However, the demand for aviation gasoline increased to the point where it was necessary for Canada to undertake the construction of alkylation plants for the production of these blending agents.

Canadian consumption figures during the first three years of the war reflect some of the problems with which the refineries have been confronted:

DOMESTIC CONSUMPTION OF PETROLEUM FUELS
EXCLUDING AIRCRAFT GASOLINE

(in barrels)

	1938	1941	1942
Motor Gasoline	22,143,892	26,268,571	23,438,833
Tractor Distillate	915,124	1,062,591	1,200,323
Kerosene	654,495	958,676	1,048,787
Heavy Fuel Oils .... }	15,260,174	6,947,087	6,964,382
Light Fuel Oil .... }		16,520,738	15,892,100
Totals	38,973,685	51,757,663	48,544,425

From the foregoing figures it is seen that Canada's requirements have increased substantially. Consumption of petroleum fuels was very much higher than the 1938 total. In addition, exports of petroleum fuels rose from approximately 127,133 barrels in 1938 to 1,758,309 barrels in 1942. The fuel oil demand increase in 1942 was 36 per cent over 1938 and would have been still higher were it not for restrictive measures. The decline in the use of petroleum fuels in 1942, as compared with 1941, reflects the result of gasoline rationing, which first went into effect on April 1, 1942.

The sources of supply of imported crude oil have changed materially since war broke out. The imports from the United States rose from more than 29 million barrels in 1940 to more than 33 million in 1942; whereas the importation from Colombia, which had increased to more than 12.6 million barrels in 1941 dropped to a mere 1.5 million barrels in 1942. On the other hand, the Venezuela imports rose steadily from 3.25 million in 1940 to nearly 9.4 million in 1942. Peru, Ecuador and Trinidad also supplied fairly substantial quantities of crude, but in 1942 these sources were cut off completely.

During the 12 months ended June 30, 1942, ocean tankers brought in 40.8 per cent of the crude oil which entered Canada, and lake tankers carried 23.2 per cent. The amount pumped by pipeline from mid-continent fields in the United States was 17.2 per cent, and 1.2 per cent came in by rail. The balance, 17.6 per cent, represented Canadian production.

Domestic Crude Oil

The first attempt in Canada to drill an oil well was in 1862 by a photographer named Shaw. This photographer was so successful that he spurned an offer of $25,000 in gold for his well, but lived to regret it when, after completion of the gusher which produced from 6,000 to 7,000 barrels a day, the price of oil dropped from $10 to 10 cents a barrel.

In those days, gasoline was a nuisance. The refiners wanted only kerosene and lubricants. They dug holes

and buried the gasoline at night, or they poured it into rivers, thus endangering life and property.

The annual production in Ontario gradually increased with the drilling of additional wells until it reached a peak of 997,495 barrels in 1894. After that, it steadily declined to about 200,000 barrels in 1914, and in 1930 was a mere trickle of 117,000 barrels. Some more recently discovered wells have been responsible for the production in recent years of between 200,000 and 300,000 barrels. The current rate is only 400 barrels a day, and the output of each well is so small that measurements are made in gallons rather than in barrels.

With the coming of internal combustion engines, the search for petroleum extended to Alberta and the Northwest Territories. Some 1,600 miles from the nearest centre of population, a well was sunk in 1920, at what is now called Fort Norman, N.W.T. This field was developed only sufficiently to supply the fuel oil and gasoline requirements in the far north, which until the advent of the Alaska Highway did not exceed 20,000 barrels a year. Military requirements in Alaska have caused the United States Army to take an active interest in discovery in this area, and potential production has been increased substantially. A pipeline road has been laid by the U.S. Army across the back of the Canadian Rockies from Fort Norman to White Horse, Yukon, on the understanding that after the war Canada can take over the whole project, which is known as "Canol." From Norman, the most northerly oil-producing field in the world, the oil will be piped to White Horse, where it will become fuel for the Alaska Highway and for the stream of giant planes waging war against Japan from the north. White Horse is already linked by a 100-mile pipeline with Skagway, Alaska, on the Pacific coast. Believed to be the most northerly pipeline in the world, before the war an 8½-mile link paralleling the Bear River Rapids had already been built to carry fuel oil and gasoline from the Fort Norman refinery to mines on Great Bear Lake.

The exploration for the Fort Norman-White Horse pipeline probably will become one of the sagas of the

north. The engineer-adventurer, given the job of surveying the route, used tractors, horses, and finally dog teams to break a way for the contractors and United States Army over unexplored territory. One of his expert guides was a 57-year-old veteran of the Dominion Land Surveyor's Office. With the aid of this surveyor and Indian guides, the caravan parties combatted wilderness temperatures which dropped to 78 degrees below zero. The parties surveyed a 600-mile stretch northeast of White Horse, which avoided gorges, ice floes and rivers.

Crude oil has been produced in New Brunswick since 1910, but the greatest rate of production attained was 85 barrels per day in 1941. The remaining production of crude oil in Canada, apart from the Turner Valley fields, comes from miscellaneous fields in Alberta, which had an output of 139,335 barrels in 1942. The largest of these is at Vermilion, the second largest, at Taber. These, and the developments at Wainwright, Red Coulee, and other fields, produce a heavy grade crude.

But the greatest oil source in Canada has been, and still is, the Turner Valley, which supplies approximately 15 per cent of Canada's oil requirements.

Crude oil was first produced from the limestone in this area at a well completed in the northern part of the valley in April, 1930. However, it was not until the completion of the Turner Valley Royalties well in June, 1936, that a substantial output was achieved. A year later Alberta experienced the first of its many oil booms. The southern part of the field was quickly developed, and further impetus was provided by the completion of a well in the north end in January, 1939, which paved the way for important northern extensions. The annual crude oil production from the Turner Valley has been as follows:

1935	730,331	barrels
1936	684,878	"
1937	2,110,052	"
1938	6,159,641	"
1939	7,259,242	"
1940	8,180,191	"
1941	9,537,221	"
1942	9,701,719	"

By November 14, 1943, a total of 224 active oil wells had been brought into production, and had a total output of 23,000 barrels a day. Of these, only 112 had been drilled before July, 1940.

A survey of Canadian production, made by the Oil Control shortly after its establishment, showed that at least 40 new producing wells would be required to maintain Turner Valley production. Unfortunately, insufficient proved drilling sites had been discovered to support such an undertaking. Turner Valley had about reached its peak and a new producing field had to be found if possible. However, more new wells are being drilled, or being prepared for drilling, than at any time in the history of western Canada.

Wartime Oils Limited

Faced with declining production in Turner Valley and with the need for maintaining the domestic output, the government decided early in 1943 to assist in drilling marginal sites on the West Flank in Township 19.

With head office in Calgary, Alberta, a Crown company, Wartime Oils Limited, was incorporated on April 4, 1943. Up to the end of 1943, the company had confined its activities to advancing money to operators for drilling. In some instances, the operators supply a part of the necessary funds; in others, the Crown company advances funds for the whole of the drilling and well equipment. The area being explored has been checked by a geologist in the employ of the Oil Control.

By the end of 1943, four new wells had been drilled into the limestone and had been tested for production. It was expected that two more wells would be drilled by the end of January, 1944, two by the end of March, two by the end of April, and two by the end of June.

Aviation Gasoline

Every time a raid over Germany is headlined in the newspapers, another more prosaic, but nonetheless imposing, story remains unwritten. To propel the warplanes a million or more gallons of the finest aviation gasoline have been expended.

For example, when the Allied air forces attacked Wilhelmshaven and Dusseldorf on November 3, 1943, approximately five million gallons of aviation gasoline were used. This is the equivalent of the capacity load of a large tanker. Thus in one day, and in only one theatre of war, the air forces consumed gasoline which it had taken 34 days to deliver to Britain.

In one day as many as 367 planes have left an eastern seaboard airport to cross the Atlantic, and each required 1,000 gallons for the trip. On the Pacific coast, additional planes take off for Russia, while thousands of planes are constantly in use in Italy, the Pacific and other theatres.

All this adds up to a greater war need for aviation gasoline than for any other petroleum product, excepting only fuel oil for the Navy.

Aviation gasoline is needed in substantial quantities in Canada as well as at the fighting fronts. Today there are 94 Air Training Schools and 18 Home War Establishments, from which air patrols set out to protect Canadian waters and to guard convoys across the Atlantic. In addition there are scores of other government airfields.

Before the advent of Oil Control, departmental officials conferred with the Canadian oil refiners to discuss the requirements of the Commonwealth Air Training Plan. They formed a committee from the industry, whose responsibility it was to ensure co-operation in meeting the need for aviation gasoline.

In 1941 and 1942, the expansion of the Commonwealth Air Training Plan was so very rapid, particularly on the prairies, that the oil industry had great difficulty in providing sufficient airplane quality gasoline. The prairie refineries did not have sufficient capacity to meet the demand, and this meant an additional burden on the eastern refineries. As a result, aviation gasoline had to be moved by lake tanker to the head of the lakes during the open navigation season and from there by tank car. During the winter, it had to be carried the whole distance by tank car.

As it is impossible to manufacture high-octane aviation gasoline without the use of a blending agent, the

industry made a practice of obtaining the maximum cut possible of aviation base material from the available imported crudes, and of blending this cut with alkylate imported from the United States.

Alkylate is the type of synthetic blending agent used to provide high anti-knock and low vapor pressure characteristics in finished aviation gasoline. It is manufactured by combining certain refinery or natural gases in the presence of a catalyst. Specifications for aviation gasoline have become more rigid in ratio to the improved performance of military aircraft. Higher engine compressions necessitate the use of a fuel to support anti-knock values, greater power output and better all-round performance.

Anti-knock value is perhaps the most important specification for aviation fuels. Knocking is caused by a rapid and uncontrolled detonation of the fuel in a cylinder. It results in rapid heating of the cylinder heads and pistons in a high-compression engine, and may lift the cylinder head off the barrel of an air-cooled radial motor. Knocking may be eliminated by using a fuel which burns slowly, thus producing a steady, powerful movement of the pistons.

Combat planes of the United States, Great Britain, and the other United Nations are using 100-octane gasoline, while Germany's aviation gasoline is believed to average 87-octane. It has been stated, however, that German engine design is such as to offset the lower-octane rating.

The advantages of high-octane over lower-octane gasoline are marked. The power output of 100-octane gasoline is 20 to 25 per cent greater than that of 87-octane gasoline, and take-off power 26 per cent greater. The greater power reduces the required take-off run of multiple-engine planes by 45 per cent. Moreover, fuel consumption is reduced by 12 to 15 per cent. This reduction enables a large plane to carry an additional load of more than half a ton of bombs in place of the extra fuel that would be required if lower-octane gasoline were used. Alternatively, the plane might carry the same load

but increase its range. In addition, the 100-octane gasoline enables a plane to achieve a higher ceiling, to climb faster and to achieve a higher speed, and to maintain its maximum speed at a higher altitude.

Under the jurisdiction of the government-owned Allied War Supplies Corporation, an alkylate plant was begun in Calgary in 1942, and went into operation in April, 1943.

Because of difficulties in obtaining supplies, the construction of a second plant was delayed. This plant will be located in Montreal East and it probably will be "on stream" in June, 1944.

Fuel Oil

By the early autumn of 1940 war demands were causing a serious shortage of oil, and it was necessary to prohibit the installation of oil-burning equipment for any purpose which would consume more than 4,000 imperial gallons per year. The order, issued on September 16, 1940, also prohibited the use of oil for heating, steam production, or process work, except where absolutely necessary to the war effort.

With demand for fuel oil still mounting, it was necessary on June 4, 1941, to broaden this order to prohibit the installation of all types of oil-burning equipment, except by permit. This restriction covered every type of industrial and domestic equipment irrespective of gallonage.

In August, 1941, the British Columbia oil suppliers, at the suggestion of Oil Control, warned their large customers that they should have their heating equipment switched to some other fuel. In November, the Oil Controller followed this up with a letter making the same request of all commercial, institutional, and industrial users throughout Canada.

While the response to this voluntary appeal was good, it proved inadequate. Accordingly, in May, 1942, a letter was forwarded to all commercial, industrial, and institutional fuel oil users, which read in part: "The use of fuel

oil for the heating of all types of buildings, including factories, warehouses, banks, office buildings, schools, churches, hospitals, institutions, apartment and boarding houses, provincial and federal government buildings, armed forces' cantonments, barracks and administrative offices, will no longer be available after July 31, 1942."

As a further measure to meet the critical situation, a month later an order was issued drastically reducing the use of asphalt, which is merely another form of very heavy fuel oil. This order prohibited, except by permit, the use of asphalt.

The Oil Control announced that the order would be applied as follows:

1. No oil could be released for use as road oil.

2. No asphalt could be used for constructing new provincial, municipal, or private roads, but some could be released for certain essential maintenance and airports.

3. Asphalt for making roofing shingles, and other roofing materials, would be released on a 50 per cent quota.

4. Asphalt for linoleum or oilcloth would be released on a 50 per cent quota.

5. Because of the threatened fuel shortage, no restriction would be placed on the use of asphalt for making coal briquettes.

6. No restriction would be placed on the use of asphalt for wooden storage battery boxes. Such boxes could no longer be made of rubber.

The distribution of asphalt for road repairs and maintenance was placed in the hands of the nine provincial highways departments, whose engineers are thoroughly familiar with conditions of the county, municipal, town, and city roads, as well as the provincial highways. The same plan was employed in dealing with the various government agencies. For example, central authorities approved applications for the three armed forces. The Department of Transport also assumed responsibility for the use of asphalt in certain construction projects.

On June 18, 1942, to make more fuel oil available, the refineries were directed to change their runs by reducing to a minimum the production of motor car gasoline. In a radio address in the same month, the Minister of Munitions and Supply urged householders to convert their equipment if possible, and warned commercial, institutional, and industrial users that they must convert by the end of July of that year.

As a result of this conversion program and of the increased production, it was possible to build up reserve stocks of fuel oil sufficient to take care of the demands for household heating throughout the winter of 1942-43, one of the most severe in history. With fuel oil consumption already up more than 62 per cent, and with demands increased for the Navy, the Merchant Navy, the Rocky Mountain divisions of the railways, and essential war industries, it was necessary to refuse permits for the installation of all types of oil-consuming equipment. Under the new system, which became effective on September 1, 1942, fuel oil was made available only by special permit, except to farmers using oil in farming operations or for the operation of a naval or merchant ship, or for heating a bona fide private residence used exclusively as a dwelling and containing not more than two families.

This new permit system made it possible to find out exactly who was using fuel oil and how much was being used. As a result, in May, 1942, it was shown that the increased demand resulting from the war totalled approximately 82.3 million gallons. This increase was more than offset by the conversion program and an additional saving of 110 million gallons was effected. A substantial portion of this total saving of 192.3 million gallons was achieved as a result of the Minister's appeal.

Early in 1943, it was feared that rationing of light fuel oil might become necessary, and an order issued on January 26 made it necessary for every householder using fuel oil to answer a questionnaire. In the autumn of the same year, the Oil Control sent all household users a bulletin outlining 22 suggestions for conservation, and much additional fuel oil was saved.

By the beginning of December, 1943, the heavy fuel oil position had eased somewhat and it was possible in certain instances to permit the transfer of oil burning equipment from one location to another. At the same time, restrictions on the use of such oil in Alberta, Saskatchewan, and Manitoba, were relaxed. Later this relaxation was extended to all the provinces, except British Columbia where heavy fuel oil was still in extraordinary demand, especially for the Navy.

By the same token, in the fall of 1943, the asphalt situation became easier and on December 1 the restrictions were removed.

Gasoline Rationing

At the height of the Battle of Britain and the Battle of the Atlantic, the necessity arose for gasoline conservation. Time would not permit a well-organized program, and a conservation appeal was issued on July 14, 1941.

Almost simultaneously gasoline stations were prohibited from selling petroleum products after 7 p.m. and before 7 a.m. or at any time on Sunday.

Before the conservation appeal was issued, gasoline consumption had risen more than 18 per cent. Assuming this increase would have continued, the voluntary saving achieved from the campaign was approximately 20 per cent. However, the supply situation continued to deteriorate and another temporary measure, quota restriction of deliveries to service stations, was undertaken. These various measures are estimated to have saved approximately 33 million gallons of gasoline, or the equivalent of 12 additional cargoes of crude oil.

After a close study of rationing plans in operation in other parts of the Empire, a plan applicable to Canada was devised in the late fall and early winter of 1941-42, and regional Oil Control offices were established to handle it. Under this original plan, to purchase gasoline a vehicle owner was required to register his vehicle with the Control at a cost of $1, and to obtain a gasoline licence and ration book. Each ration book permitted the purchaser a designated number of units of gasoline, according

to the category of the vehicle for which it was issued. At the outset the unit represented the right to purchase five gallons of gasoline. After progressive reduction, the unit value stood throughout Canada at three gallons on October 17, 1942, and has remained at that figure ever since.

The 1942 plan classified every vehicle within one of seven categories: "A," "B," "BX," "C," "D," "E," and Commercial. Under each category, with the exception of the commercial, three classes, grouped by makes of cars, were provided, and to each of these classes was assigned a different number of units. In the first class were placed all small passenger cars, in the second class the medium-size passenger cars, and in the third class the larger passenger cars. This distinction between types of passenger cars was abolished in 1943.

Shortly after the rationing plan went into effect on April 1, 1942, the oil position had become so grave that it was necessary to revise downwards the allocation for vehicles in the higher categories and at the same time work was begun on a modification of the original system.

On February 11, 1943, the Minister announced in the House of Commons a new system which was to go into effect on April 1, 1943. With only minor changes, this same system will remain in effect during the rationing year, 1944-45.

The new system provided a basic allowance for every passenger car, plus an extra allowance tailored to meet the proved, individual needs of car owners eligible for a special category.

Each of the 1,220,000 passenger cars in Canada is allowed a basic Category "AA" ration book. At 18 miles to the gallon, and with the unit at three gallons, each such car could thus be driven, during the rationing year, a basic 2,160 miles.

Those who were eligible and could prove their need of a special category were allotted a fixed number of extra coupons for their vocational needs.

Some owners in a special category might be allowed only a portion of a special ration book; others might

be granted two or more books, or portions of books, according to their proved needs. Two cars in the same category did not necessarily receive the same allowance. For example, one holder of an "A" might be permitted only 1,000 miles of additional essential driving, while another in the same category might be allowed 3,000.

The new plan made it mandatory for every truck and car to bear a windshield sticker, indicating its category. Cars belonging to ARP workers and employee-drivers under the Wartime Industrial Transit Plan, bore respectively either an "ARP" or "WIT" sticker, and Commercial category vehicles bore a "T" sticker. In 1944 stickers marked "Taxi" and "U Drive Taxi" also were provided.

The 15,200 motorcycles in Canada came within only two categories. The category for all non-commercial motorcycles was known simply as "Motorcycle," and allowed the owner a fixed ration of 16 units. The "Commercial Motorcycle" category allowed perhaps less than, but no more than 85 units for the year. Motorcycles did not bear windshield stickers.

The tourist from outside Canada is not required to carry a sticker on the windshield of his car. He is permitted four units for his car per year, or one unit and a third for his motorcycle.

Rationing of commercial vehicles is required and each application is approved according to proved needs. The 330,000 commercial vehicles in Canada come within two classes: "Transit" and "Services." In the "Transit" Class are included ambulances, buses, taxis, and drive-yourself cars, and these are granted only enough to drive the mileage authorized from time to time by the Transit Control. The "Services" class covers all other commercial vehicles and the Services Administrator of the Wartime Prices and Trade Board classifies the vehicles in the "Services" group, and determines the mileage which will be granted each type of vehicle.

At the outset of the new rationing year, the owner of each commercial vehicle is told how many units he will be allowed.

The rationing plan also applied to watercraft. Commercial watercraft require a licence, but the operators pay no licence fee and use no coupons. They buy the same marked gasoline that is sold for farm tractors and stationary engines.

Non-commercial marine engines must also be registered with a regional office of the Oil Controller. Upon payment of a registration fee of $1, coupons are issued in exchange for which graded gasoline, as used in automobiles, may be purchased.

All non-commercial marine engines are placed in one of two categories. Non-commercial marine category "A" covers pleasure craft only. Non-commercial marine category "B" covers essential transportation. The use of gasoline for aquatic regattas, races, and similar events is prohibited.

The non-commercial marine allowances are as follows:

OUTBOARD MOTORS

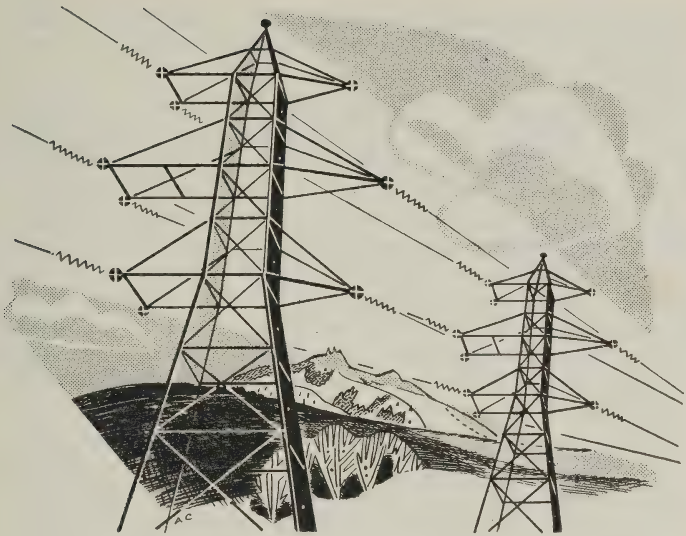
2 H.P. and under	1¼ units
Over 2 H.P. but not exceeding 5.9 H.P.	2 units
Over 5.9 H.P. but not exceeding 10 H.P.	2½ units
Over 10 H.P.	3 units

INBOARD MOTORS

10 H.P. and under	2 units
Over 10 H.P. but not exceeding 20 H.P.	3 units
Over 20 H.P. but not exceeding 30 H.P.	4 units
Over 30 H.P. but not exceeding 40 H.P.	5 units
Over 40 H.P. but not exceeding 50 H.P.	6 units
Over 50 H.P. but not exceeding 60 H.P.	7 units
Over 60 H.P. but not exceeding 70 H.P.	8 units
Over 70 H.P. but not exceeding 80 H.P.	10 units
Over 80 H.P. but not exceeding 90 H.P.	12 units
Over 90 H.P. but not exceeding 100 H.P.	14 units
Over 100 H.P. but not exceeding 125 H.P.	16 units
Over 125 H.P.	18 units

Internal combustion engines for farm and industrial use are allowed gasoline under the rationing plan, but such gasoline is "marked" by a distinctive color. In eight of the provinces, all marked gasoline is dyed purple. In Saskatchewan, to coincide with existing provincial regulations, the gasoline for farm tractors and machinery, other than trucks and private cars, is dyed purple, but the gasoline for other industrial purposes, including the gasoline for commercial marine engines, is dyed green.

Interchange of gasoline between vehicles, or between marine engines and vehicles, is prohibited. It is an offence to use marked gasoline in a vehicle bearing provincial licence plates or in a non-commercial marine engine. For the 1944-45 ration year the coupons are being revised. Every holder of a gasoline ration book issued in respect of a licensed motor vehicle will be required to write, in ink, his motor vehicle licence number on each coupon immediately upon receipt of his ration book, and service station attendants will be prohibited from accepting coupons which do not bear the correct motor vehicle licence number.



POWER

ALL previous Canadian records for the installation of new electric power facilities and for the production of electricity were surpassed in 1943, and Canada now ranks among the nations of the world as probably the greatest per capita consumer of the "white coal" which lights homes, cooks food, milks cows, washes clothes, brings in radio entertainment, and powers 80 per cent of industry.

This newly achieved position results not merely from the record capacity increase of last year, but from the total wartime increase totalling about 1.74 million horsepower. Thanks in large measure to this increase, Canada has more than doubled its industrial output, is now the third trading nation in the world, and holds fourth place among the United Nations as a producer of war supplies.

When the war is won, the increase will give Canada a new status in world affairs, but in the meantime the

added capacity must be diverted to war and other essential purposes. Over and above operational needs there is no power margin.

Before hostilities began, this country was blessed with surpluses of power, extracted from its mighty rivers by the skill and enterprise of its electrical engineers. Had they not planned wisely, Canada would not now possess the largest aluminum plant in the world, a plant which, expanded nearly sevenfold since war began, now supplies 32 per cent of the Allied requirements. Nor would Canada be turning out sufficient magnesium for her own needs and for export. Nor would ammunition, guns, tanks, warplanes, and other war matériel be streaming in enormous quantities from Canadian factories.

When the French pioneers at Port Royal harvested Canada's first recorded grain crop in 1605, it took them many weary hours of hand grinding to make their flour. Two years later they built a water-driven mill at nearby Laquille River, believed to be the first such mill operated on this continent. From this humble beginning water-power development and agriculture progressed along parallel lines until a little more than 50 years ago, when electric dynamos and high voltage power transmission began spreading water-generated energy all across Canada.

It took Canada half a century to bring power installation up to 8,190,772 horsepower in 1938. On the day Germany attacked Poland, the figure stood at 8,289,212, and this total did not change materially during the balance of 1939. In the subsequent four years new developments, including the gigantic Shipshaw undertaking, added 1,745,301 horsepower, an increase of about 21 per cent. Thus the total installation stands at 10,034,513 horsepower, to which at least 68,000 will be added in 1944. Yet great as this total is, it still leaves more than 80 per cent of Canada's minimum water-power resources available for future development as the need may arise.

The virtual completion of the Shipshaw project was responsible for the record-breaking increase during 1943.

Of the 1,002,273 horsepower installation in the twelve-month period, 740,000 was at this one undertaking. Because this 1943 installation total includes the capacity of three units transferred to newer stations, and also includes certain other adjustments, the net increase was 810,973, which still tops that of any year in Canada's history.

More than 90 per cent of Canada's total hydraulic development is installed in central stations distributing electricity to the public, and these stations generate more than 98 per cent of all electricity sold in Canada or exported to the United States. With the exception of January, the output of each of the first ten months of last year showed a substantial increase over the corresponding month of 1942. The total output is estimated at 40 billion kilowatt hours as compared with 37.2 billion in 1942. The 1939 figure was only a little more than 28 billion. Every 54 days Canada now produces as much electricity as in a whole year during the war of 1914-18.

The enormous demand for power which sprang up within a few months after the declaration of war was promptly met by a diversion of existing supplies from peacetime uses. As war loads progressively increased, all possible secondary power was channeled into primary production. Daylight saving time was continued throughout the winter months, and some non-essential users were curtailed.

Inter-connections between power systems were made more elastic and of greater capacity, and thus power was shuttled from points of lower demand to points of the greatest need. Power has been loaned from time to time between the United States and Canada. In times of breakdown it has been transmitted to the United States at Niagara and taken from the United States at Massena, or vice versa, depending on the requirements of the moment. In all respects the relations between the Canadian and United States controls have been co-operative.

International arrangements were made to utilize more of the flow of the Niagara River, and to increase this flow. Before the war the Long Lake, Ontario, diversion had

been completed, and to this was added the Ogoki diversion. This project, put into operation in 1943, consists essentially of a dam at Waboose Rapids on the Ogoki River in northwestern Ontario to divert the river's flow southward by way of Mojikit Creek and Jackfish River into Lake Nipigon. The water thus diverted is now available for augmenting power generation in plants on the Nipigon River. It thereafter flows into Lake Superior together with water already diverted from Long Lake, and increases the flow at Niagara and elsewhere in the Great Lakes System, thus adding a potential of 360,000 horsepower to the Great Lakes-St. Lawrence Waterway System.

A submerged weir was built jointly by the United States and Canada in the Niagara River above the Falls. The purpose of the weir is to raise the water surface in the Grass Island Pool sufficiently to compensate for increased use of water by the generating plants on both sides of the river, and to offset ice difficulties. The weir had the added advantage of redistributing the river flow to maintain the beauty of the Falls and rapids.

As speedily as possible these and other new developments were commenced and rushed to completion, and new units were added to existing power stations. But the biggest project of all was Shipshaw, which increased the effective capacity by 1,020,000 horsepower plus 20,000 horsepower added to its Chute à Caron plant.

Most of the new projects have been built in Quebec and Ontario, the central provinces which produce 81 per cent of the Dominion's industrial output. Except for an undeveloped lignite field in the James Bay area, these provinces are without native coal, but they make up for this lack by including within their borders more than half the total available water-power resources and almost 83 per cent of the developed water-power of the Dominion.

Quebec

Quebec boasts more than 56 per cent of the installed capacity of Canada. Notwithstanding the heavy demands of the province's own industries, its central electric

stations, which operate nearly 93 per cent of the total installation, are able to export approximately 25 per cent of their output to Ontario.

All the power companies in Quebec have greatly increased their output since the war began, and the total installed capacity on January 1, 1944, stood at 5.67 million horsepower.

In the past four years much work has been done to increase water storage facilities, and to inter-connect the various producers both within and without the province. Apart from Shipshaw, developments adding power capacity since the end of 1939 comprise: A project of the St. Maurice Power Corporation at LaTuque, 222,500 horsepower; four new units of 53,000 horsepower each at Beauharnois; a Quebec Streams Commission development on the Upper Ottawa River, 48,000 horsepower; a Pembroke Electric Company addition at Black River, 2,200 horsepower; additions totalling 8,000 horsepower at Shawinigan Water and Power Company's LaGabelle and Grand'Mère developments; a new generator at Shawinigan's Rapide Blanc plant, 40,000 horsepower; a second unit at the Belleterre Quebec Mines' station on the Winneway River, 1,400 horsepower; a new station on the Moulin à Baude River, erected by the Municipality of Tadoussac, 350 horsepower; an additional La Sarre Power Company unit at Rapid No. 5, 400 horsepower; and a new plant built by St. Eugène de Guiges Electric Company at the outlet of Cameron Lake, Temiskaming County, 250 horsepower.

Among the many new transmission lines, is a special conduit under the City of Montreal to permit the power produced from St. Lawrence River water, which has a steady flow, to be transmitted from midnight to 6 a.m., as well as during other hours in the summertime, to other parts of the province where water storage can thus be built up in those off-peak hours.

The Quebec Streams Commission, appointed and financed by the provincial government, maintains the desired regulation of flow on controlled rivers. It now controls 21 reservoirs on the St. Maurice, St. Francois,

Gatineau, North, Ste. Anne de Beaupré, Métis, and Lièvre Rivers, and on Lake Kénogami.

Ontario

Ontario, like Quebec, has abundant water-power resources. The Hydro-Electric Power Commission, owned by the people of the province, operates plants aggregating more than 75 per cent of the total hydro installation of the province and serves some 900 municipalities. It has some 20,675 miles of rural lines providing the needs of about 131,000 consumers. Ontario had, on January 1, 1944, a total installed capacity of 2.67 million horsepower.

In addition to the Ogoki diversion and the improvements at Niagara, wartime power developments in Ontario include: An installation at Barrett Chute on the Madawaska River, 56,000 horsepower; a new plant at De Cew Falls, which draws Lake Erie water from the Welland Ship Canal, and was made possible by the increased flow of water in the Great Lakes System resulting from the Long Lake and Ogoki diversions, 65,000 horsepower; the Big Eddy development on Musquash River, 9,900 horsepower; and an additional unit at the Ear Falls Development on the English River, 7,500 horsepower.

These projects were all undertaken by the Ontario Hydro-Electric Power Commission. This publicly owned corporation also added hundreds of miles of transmission lines, including a 110,000-volt line, 120 miles long, from Port Arthur to the Steep Rock iron mine project at Steep Rock Lake. This line is now providing the power to pump an estimated 100 billion gallons of water from the lake to expose the ore body. Power also will be supplied to a pulp and paper company which could no longer operate its Moose Lake station, which had depended on the flow of water in the Steep Rock area.

In addition to the commission's projects, a private company, the Great Lakes Power Company, built two unit additions, one at the Upper Falls, the other at the Lower Falls, on the Montreal River, totalling 21,400 horsepower of increased capacity.

At the newly built synthetic rubber plant near Sarnia, Ontario, the government is installing the largest steam and steam-power plant in Canada. Most of the steam is used in the various processes for making rubber, and the remainder activates three turbo-generators with a rated total capacity of 29,000 horsepower.

British Columbia

Second only to Quebec in available water-power resources, British Columbia has a total installation exceeded only by the two central provinces. On January 1, 1944, British Columbia had a total installed capacity of 796,000 horsepower.

The most notable wartime development in British Columbia has been on the Kootenay River, where the West Kootenay Power and Light Company installed two 25,000-horsepower turbines at its Upper Bonnington station. It now has under construction a new generating station at Brilliant on the same river. Two turbines of 34,000 horsepower each are being installed, with provision for two similar units. This is the company's fifth station on the Kootenay, and its full installation will provide a total of 414,000 horsepower. The power is almost entirely used in mining, smelting and electro-chemical operations.

In addition, the smelting company which controls West Kootenay Power and Light Company, is carrying on preliminary work on a power site on the Nation River to provide electricity over a 60-mile line to its Pinchi Creek mercury property.

The West Canadian Hydro-Electric Corporation installed a second unit of 3,800-horsepower at Shusway Falls, and the Canadian Fishing Company added a 235-horsepower turbine at Butedale.

The Prairie Provinces

Of the three prairie provinces, Manitoba has the greatest power resources, and the greatest development, almost 70 per cent of the total prairie installation being on the Winnipeg River. The districts containing the least water-power—the southern areas of Alberta and Saskatchewan—have large coal and oil resources.

The largest wartime power project in the prairie provinces was at Minnewanka Lake where the Calgary Power Company built a reservoir and a 23,000-horsepower generating station on Cascade River near Anthracite. In addition a smaller dam on the upper reaches of Ghost River near Blackrock Mountain diverts part of the flow of that stream into Lake Minnewanka.

The same company augmented its storage reservoir on Upper Kananaskis Lake. This storage, together with that of Lake Minnewanka, augmented the supply of power at the company's three generating stations on Bow River.

In Saskatchewan the Churchill River Power Company constructed a dam at Whitesand Rapids at the south end of Reindeer Lake to provide additional water storage for the generating station at Island Falls.

In conjunction with the Department of National Defence, the Manitoba Power Commission constructed a substantial mileage of transmission lines to serve airfields and other war projects.

Maritime Provinces

The water-power resources of the three maritime provinces, while small in comparison with the sites in the other provinces, constitute a valuable economic resource, and their output is supplemented by power from abundant indigenous coal supplies.

The chief wartime development in New Brunswick was the installation by the New Brunswick Electric Power Commission of a new 10,000-horsepower steam turbine at its Grand Lake station.

The Nova Scotia developments comprise: The installation by the Nova Scotia Power Commission of a small new generating station at Barrie Brook to serve the area near the Gut of Canso, and of a 900-horsepower station at Eel Lake on Medway River; two new generating stations of the Avon River Power Company, one at Hollow Bridge, the other at Hell's Gate, totalling 11,000 horsepower; and a 4,000-horsepower turbo-generator installed by the Town of Truro.

Additional steam turbo-generators are being installed at the Halifax plant of the Nova Scotia Light and Power Company, and by the Mersey Paper Company at its Brooklyn mill.

Shipshaw

One of the largest power projects in the world, the Shipshaw plant of the Aluminum Company of Canada Limited has a total minimum installed capacity of 1,300,000 horsepower, which is almost double the capacity of the next largest plant in Canada.

In spite of wartime shortages of materials and man-power, and in spite of the heat and blackflies of summer and the bitter sub-zero cold and snows of winter, the 1,020,000-horsepower extension to the original Shipshaw plant was completed in the 27 months from the beginning of October, 1941, to December, 1943.

The huge engineering project, designed to provide additional power to increase the output of aluminum, cost more than $105 million. Its size can best be realized when it is understood that more than 5.5 million cubic yards of earth had to be removed. Nearly 3.25 million pounds of dynamite were used in the construction work, and in one explosion alone—that which blew out the great wall of rock which temporarily restrained the whole weight of the Saguenay River—83,000 pounds of dynamite demolished 18,000 cubic yards of solid rock. In this immense explosion, equal in effectiveness to four super block-busters all going off at once, 500-pound chunks of rock were tossed a thousand feet into the air.

The planning and preliminary work connected with the Shipshaw development was underway in 1926, a year after the Aluminum Company first purchased land for the erection of its now-vital plant at Arvida, Quebec. The first phase of the development, comprising four 65,000-horsepower generators completed in the early 30's, became known as Chute à Caron, although officially called Shipshaw No. 1. The new development is Shipshaw No. 2.

The name "Shipshaw" arises from the fact that early plans called for the diversion of the Saguenay waters through the powerhouse and into the Shipshaw River. As matters developed, it was found to be quicker, although more costly, to empty the water back into the Saguenay.

To realize the gigantic proportions of the whole development it is necessary to study a map showing how the great Saguenay River is fed by a maze of lakes, streams and rivers from an area of 28,000 square miles. Much of this water rises hundreds of miles north, in the latitude of James Bay. From there it flows down the Peribonka, Chamouchouane, and Mistassini Rivers into Lake St. John. It then empties out of that lake into the Saguenay, which later joins the St. Lawrence.

In order to control the flow through the turbines of the Saguenay, it is necessary to control the flow of water down the river. To do this, dams were built far north of Lake St. John.

One such dam, completed early in 1943 as part of the Shipshaw program, is located at Passe Dangereuse. It is a huge dam which will hold a reservoir of water in the Peribonka River. To undertake this project, men, equipment, and materials had to be carried more than 130 miles from the nearest railhead, and a new road, 60 miles long, had to be cut through the wilderness. To build another of these dams, that on the Manouan River, airplanes had to be used to carry in all the materials, equipment and men.

When the war broke out the Chute à Caron installation had a capacity of 260,000 horsepower. Its four 65,000-horsepower units were stepped up to 70,000 each, and two additional similar units were temporarily installed. Under the lower head available at this site these additional units developed only 55,000 horsepower each. When the Shipshaw development farther down the river was nearing completion, these temporary installations were moved to the new site, and there, under a greater head of water, they developed 85,000 horsepower each. Ten other 85,000-horsepower units also were installed at

Shipshaw. Thus the four 70,000 units at Shipshaw No. 1 and the twelve 85,000 units at Shipshaw No. 2 have a total capacity of 1,300,000 horsepower.

Power Control

Because a majority of the large wartime industries are located within the borders of Ontario and Quebec, the most pressing power problems have obtained in those provinces.

Less than a year after Canada declared war, shortages of electricity in Ontario and of adequate capacity in Quebec loomed as probabilities. On August 23, 1940, a Power Controller was appointed with headquarters in Montreal.

The Control began at once a study of the power capacities and loads, both actual and potential, in each province. The provincial organizations in charge of power were consulted and their co-operation obtained. These organizations became, in fact, the agents of the Control.

The first major conservation move initiated by the Control was an order-in-council passed on September 20, 1940, which made daylight saving applicable all year round in those municipalities in Ontario and Quebec which had advanced their clocks during the summer of that year. More than two years later, on January 26, 1942, the order-in-council was amended to extend daylight saving throughout the whole of Canada.

By arrangement, all use of electricity for space heating and to produce steam, was banned in the fall of 1940, and in various localities control devices were installed on domestic hot water heaters so that the power would be shut off during peak hours. Thus secondary power was made available for immediate use in primary loads.

The Control learned that in all the provinces, except Alberta, small surpluses of power at that time were available. In Alberta it was necessary to provide a block for a large electro-chemical munitions industry. The problem was chiefly one of adequate water storage.

It was solved by the construction of storage facilities at Lake Minnewanka and the erection of a power plant just below that site.

The peak requirements of the winter of 1940-41 were met without the need for further restrictions, but it was evident that, with war industry expanding rapidly, measures would have to be taken to provide large blocks of power if an alarming shortage were to be avoided in the winter of 1941-42. In conference with the provincial authorities, the power companies, the Ontario Hydro-Electric Power Commission, and the Quebec Streams Commission, it was decided to embark on large-scale projects.

These projects included the inter-connection of the power systems; the erection of an underground circuit across Montreal; the building of a new transmission line from Trois Rivières to Quebec; the construction of additional storage dams; the diversion of more water for the Niagara plants; and the building of new units and of new power stations in Quebec and Ontario.

At the same time the Co-ordinator of Production of the Department was advised that no further arrangements should be made for war industry expansion without prior consultation with the Power Control. This was particularly important at that time, when material shortages were making it difficult to obtain transmission wire, generators, and other requirements. The shortage of transformers became so acute that it was necessary to halt the installation of rural extensions.

The enlarging aluminum program also caused concern. Power for the pots at Beauharnois was made available by dredging the intake canal and enlarging the tailrace. Power for the LaTuque pots was provided by a new generator at LaTuque, a new generator at Rapide Blanc, and new storage facilities on the upper reaches of the St. Maurice watershed.

With the approach of the critical winter of 1942-43, it became necessary to restrict certain civilian uses of power. In the shortage areas of Quebec and Ontario, the Controller prohibited the use of electricity for

advertising signs, show windows, certain outdoor lighting, and other non-essential purposes. He ruled out highway lighting and reduced street lighting by 20 per cent. He appealed to the public in those areas to reduce domestic consumption by 20 per cent. And in co-operation with the Metals Controller, new connections were limited. At the same time the Controller embarked on a broader policy of denying non-war industries the power they sought.

The winter of 1942-43, which broke long-standing records for blizzards, freezing rain, sub-zero temperatures, and attendant conditions such as road blockage, electric wire breakage, and interruption of transportation and communication service, plus an unusually late ice break-up, combined to test power facilities almost to the breaking point. Although at one time during the winter no margin whatever was available, it was not necessary at any time to curtail war production for lack of power.

As a result of ice and water difficulties the generating capacity in the Cedars and Beauharnois areas were severely reduced. To meet this situation, water storage in the Shawinigan and Saguenay areas was drawn upon to a dangerous extent. This, in turn, made it necessary to obtain power from the Ontario Hydro-Electric Power Commission for Quebec use, and to curtail the exportation of power to Massena, New York.

Without the inter-connection between the Ontario and Quebec systems, and without the savings achieved through mandatory and voluntary restrictions, the additional power would not have been available when needed. The experience of the winter indicated the advisability of further extension of the inter-connecting lines, and in the summer of 1943 more such lines were built.

With the completion in 1943 of a record new capacity, it became possible to assist agriculture in its task of increasing food production by permitting the extension of electric service to certain farms. Before the year was over several hundred such installations had been made.

Restrictions on power use by pulp and paper mills in Quebec were removed in 1943, but because of the shortage of wood this action did not result in any increase in power consumption.

An apparent power shortage has developed recently in parts of British Columbia, but it is believed that by the imposition of temporary restrictions and with the addition of new facilities, sufficient electricity will be made available.

Given average weather conditions, and with the continued avoidance of waste, the electrical requirements of the country will be met in 1944.

RUBBER

CANADA is winning the race for rubber. For the first time since Pearl Harbor, the home front can breathe more freely, confident at last that the armed services will not be handicapped for lack of this essential commodity.

On the site of an old Indian reservation, one mile from Sarnia, Ontario, a plant owned by the people of Canada in substantial production at the close of 1943, soon will be turning out 34,000 long tons of buna-S and 4,000 long tons of butyl each year.

This output, together with small quantities of neoprene from the United States, the still-essential natural rubber from Ceylon, Mexico, Brazil, and Liberia, and goodly supplies of scrap, will be sufficient to provide Canadian wartime requirements.

Still vitally necessary for the carcasses of large Army, Air Force, and essential civilian truck tires, for surgical equipment, for certain cements, and for certain other purposes, natural rubber is in seriously short supply. As compared with a consumption of 60,000 tons in 1941, Canada will have to make do with only 10,000 tons in 1944. The normal peacetime consumption is about 35,000 tons. In 1944 the total consumption of rubber and its substitutes will be on this basis: natural rubber, 20 per cent; reclaim, 25 per cent; synthetic rubber, 55 per cent.

The existing supplies of natural rubber, as well as the output of synthetics, have been earmarked for direct and indirect war and essential civilian purposes.

As a result of measures adopted by Rubber Control, consumption of rubber for civilian purposes averaged in 1943 about 10 per cent of what it was before the war. Of this 10 per cent, tires have been provided for essential vehicles, but since Pearl Harbor no tires have been made for the non-essential car.

Restrictive orders were not alone responsible for this saving of the priceless rubber supply. Much of it has been achieved by the use of substitutes and reclaim in the manufacture of hundreds of essential articles, including war supplies. This progressive reduction in the use of rubber is still going forward. Month after month the technical experts in the Control are devising new formulae for substitutions, and as soon as these have been tested their adoption is made compulsory.

Midway through 1943, dealers' supplies of used tires were virtually exhausted. It thus became necessary to place such tires in the same category as retreaded tires under the rationing regulations which had been in force since early in 1942.

It was found possible, however, to employ a limited amount of buna-S rubber, imported at first from the United States, for making small quantities of synthetic tires for vehicles eligible under the rationing regulations. At the same time the making of all-reclaim tires, started early in 1943, was discontinued.

Although crowned with a success hardly believed possible two years ago, the experiment of using synthetics has caused the tire manufacturers many a headache. Practical results have been achieved which more than justify the optimism of those who dared to translate a laboratory dream into a commercial reality. But much research remains to be done before synthetic rubber fully replaces the natural product.

The chief problem faced by the technicians is the making of large-size tires for the armed forces and for essential civilian vehicles. Not as flexible as natural rubber, the synthetic product has a tendency to heat up at high speed, under an excessive load, if under-inflated, or under bad driving conditions.

At the close of 1943, however, technicians had developed new techniques in tire manufacture, and were turning out a large-size tire, containing from 30 to 40 per cent buna-S rubber, and built with rayon fabric instead of cotton. In the toughest of Army tests, the new tire is proving itself, and it is believed that it will perform satisfactorily.

With further experimental work it may yet be possible to make large all-synthetic tires. The laboratories, which several decades ago tackled the equally difficult problem of making natural rubber tires that would not puncture every 25 miles, are reasonably confident that they can solve this new problem.

Meanwhile, synthetic rubber products for the armed forces, and for essential civilian use, must undergo rigid quality tests, and none is released unless it is satisfactory for the task it is to perform.

At the beginning of 1944, the control situation was this: New, retreaded and used tires, and new and used tubes, were rationed, with 120 Rationing Representatives handling the machinery of equitable distribution to essential users. Crude rubber is permitted only for a continually diminishing list of the most essential articles. On the other hand the use of synthetic is being steadily and rapidly extended for war and essential civilian purposes.

The proportionate use of rubber supplies, both natural and synthetic, during 1943, is indicated by this table:

Item	Percentage
Airplane tires	1.0
Bicycle tires	.1
Other tires	81.9
Repair materials, including camelback	1.1
Automotive parts	.3
Bogey wheels	4.7
Airplane parts	.5
Belting	.9
Hose	.9
Gas masks	.5
Mechanical goods	1.4
Wire and cable	1.9
Waterproof footwear	3.7
Medical supplies	.4
Protective clothing	.2
Cements	.4
Miscellaneous	.1
	100.00%

(In the foregoing table war and civilian consumption are lumped together. With the whole of Canada virtually on a war footing, and with all non-essential uses prohibited, it is no longer possible to distinguish between war and essential civilian requirements.)

Historical

Fearing the possibility that Japan might become an Axis co-belligerent, Canada determined early in 1940 to obtain reserves of rubber.

A government agency, Fairmont Company Limited, was established on May 16, 1940, and given the authority to purchase, stockpile, and sell crude natural rubber in accordance with existing and subsequent war needs. By the time rubber was placed under the jurisdiction of the Supplies Control on August 26, 1941, the Fairmont reserve amounted to 25,000 tons.

It was soon evident that this was not enough. War clouds over the Pacific were taking on a deeper hue, and the shipping situation was becoming worse. With these factors in mind, the Controller arranged that Fairmont should be given a monopoly over buying and selling crude rubber, and that the stockpile should be doubled as soon as possible.

At the same time, the Control began a program of progressive restriction on the use of natural rubber. To this end, it enlisted the co-operation of an advisory committee representing the manufacturers of tires, footwear, wire and cable, and miscellaneous items.

When Canada declared war on Japan, things moved fast. Within three days all civilian dealings in new tires and tubes had been prohibited, except by permit. One day later all processing of crude rubber for civilian purposes was frozen. Four days after that rubber prices were fixed. And the day after Christmas the first step toward synthetic production was taken with the setting up of a rubber substitutes advisory committee.

Meanwhile, the Control officers, many of whom had been hurriedly recruited from the rubber processing companies, worked days, nights, Sundays and on Christmas day, to turn out a temporary, workable plan for restricting rubber consumption.

On January 5, 1942, an order was ready for signature. Under it, the sale of new tires and tubes was limited to such persons as doctors, nurses, ambulance operators, police, firefighters, bus operators, and some essential businesses and public services. With the experience gained from this order, it became possible to issue amended orders, each in some respects more stringent than its predecessor.

Even before the Japanese had engulfed Malaya and the East Indies, the magnitude of the disaster as it affected rubber supplies became apparent. In conjunction with the United States, the United Kingdom, and other Allies, all stocks of natural rubber were pooled for the joint use of the United Nations.

Also in co-operation with the United States, a program for the development of synthetic rubber was inaugurated, and by the end of March, 1942, Canada had set up a Crown company, Polymer Corporation Limited, which was to arrange for the building and operation of a rubber plant.

During the next few months the Allied rubber position grew progressively worse, and it was felt by

the Department of Munitions and Supply that the regulation of rubber in Canada was important enough to justify an individual control. Accordingly, on November 2, 1942, the jurisdiction over rubber was removed from the Supplies Control, the new Rubber Control was established, and the official who had held the post of Supplies Controller was named Rubber Controller.

With the shortage still only in prospect, the first rubber order, issued in September, 1941, was mild in its effects on the manufacturer and the consumer. It called for progressive reduction at the rate of ten per cent per month in the use of crude for civilian purposes. The bottom was to have been reached in February, 1942, when manufacturers were to have been allowed 70 per cent of what they consumed in the year ending May 31, 1941, the basic period.

But events soon outdated this order. At the beginning of 1942, shortly after Pearl Harbor, the release of crude for civilian purposes was cut in half. Thereafter it was reduced to 45 per cent of the basic period consumption, and in effect was progressively reduced to 10 per cent by prohibiting entirely the production of numerous non-essentials and by reducing or eliminating the rubber content in many others.

The rubber processors have been under very tight control, and the rubber they have used, whether for war or for civilian manufacture, has had to be processed according to mandatory specifications. No rubber has been released, even for war purposes, except by permit, and no part of the civil allotment could be carried over from one month to the next.

At the close of 1943, applications for civil allotments of natural or synthetic rubber were considered only for the following list of essentials in accordance with the most recent rubber order:

1. Medical, surgical, and laboratory supplies, and druggists' sundries for feeding of infants and care of the sick.

2. Jar rings and sealing compounds for canning of foods (beverages excepted.)

3. Protective clothing for certain workers in essential services and industries.

4. Mechanical rubber goods, hard rubber, and compounded latex for industrial equipment and for the repair of industrial plants and mines, for firefighting equipment, for agricultural equipment such as belting or hose, for fire departments, transportation companies, and public services.

5. Component parts, not otherwise specifically mentioned, made wholly or partly of rubber for incorporation in articles of various kinds, if the use of rubber is necessary in their manufacture.

6. Rubber compounds for use in making essential insulated wire and cable.

7. Suction and gasoline hose.

8. Essential plumbers' supplies.

9. Tires and tubes, including bicycle tires, as directed by the Controller.

10. Tire repair materials, other than tire repair kits.

11. Camelback for retreading.

12. Automotive parts, if the Controller has first stated in writing that the use of rubber is necessary.

13. Rubber cement for the shoe trade, on a restricted basis, or for such other purpose as may be determined by the Controller.

14. Staple black lines of waterproof footwear.

Tires and Tire Rationing

Whether in peace or in war, more than three-quarters of Canada's rubber goes into tires and tubes.

Immediately following Pearl Harbor, one of the first restrictions was a ban on the manufacture of new passenger tires and tubes. After this ban had been in effect for a little more than a year the existing inventories had dwindled, used tires and tubes were difficult to

obtain, and it was felt that, if absolutely essential cars were to be kept on the road, the ban would have to be modified, but that reclaim instead of crude would go into any new passenger car tires to be made.

Accordingly, the manufacturers started making new reclaim tires at the rate of 10,000 a month, or about a fourth of the pre-war rate. Useful only as a stop-gap, the reclaim tires had to be driven slowly and carefully. Their sale was confined to essential users eligible under rationing restrictions.

Shortly after supplies of buna-S rubber became available late in 1943, the use of this synthetic in passenger car and small truck tires became mandatory. Today such tires contain no crude rubber, except a small percentage used in the cement.

No truck tires under seven inches were made from the day of the freezing order until the second half of 1943, and production of larger truck tires for civilian use was on a very restricted basis. At the beginning of 1943, about 10,000 civilian truck tires of all sizes were being produced each month. Before the end of the year this was increased to the present rate of 15,000 a month.

During the early period of the rubber crisis, the larger truck tires were made from a mixture of crude and reclaim. Now, however, medium truck tires are made from synthetic and natural rubber is used in such tires for cement only. The largest truck tires require at least 30 per cent natural rubber to avoid disintegration from overheating. The owners of all synthetic tires, particularly truck tires, have been warned that such tires must be properly inflated, not over-loaded, and not driven at more than 35 miles an hour.

The first tire restriction order, of January, 1942, permitted essential users to purchase new tires and tubes on completion of an essentiality certificate. The weakness of this procedure soon became apparent, and it was superseded on May 15, 1942, by a rationing order.

Under the new order, a tire rationing representative was appointed for each of the Wartime Prices and Trade

Board prices and supply offices throughout Canada. The function of the representative was to investigate all applications for new and retreaded tires, retreading services, and new or used tubes. Each such application had to be supported by a certificate from an authorized dealer to the effect that the turn-in tire was so worn that it could not perform its required service. Tire ration permits were issued only to those whose vehicles were included in the list of eligibles.

This list of eligible vehicles was divided into three classes:

A. Vehicles for which new, retreaded or used tires, or new or used tubes could be bought, including public vehicles, farm tractors and combines, and vehicles used for transporting construction materials and essential commodities. Doctors' cars also were in this category.

B. Vehicles for which retreaded tires, or retreading services, or used tires and tubes, could be purchased. In this group were included vehicles used by rural mail carriers, Red Cross field secretaries, certain munition workers, and others.

C. Vehicles eligible for used tires and tubes only. In this category were included vehicles used by such persons as newspaper reporters, rural school teachers, scrap collectors, and others dependent on a car to earn their living or to perform an essential service.

At first, tire ration permits were required only for new tires, new tubes, retreaded tires, or retreading services. Used tires could be bought by anyone in the eligible list, merely by filling in a form in which the purchaser certified that the tire was essential in his work. However, used tires soon became scarce, and in July, 1943, dealings in such tires were placed on a permit basis.

Modifications, some of greater severity, some of less, were made in the list of eligible vehicles, but basically it has remained the same as in the original order.

It has been estimated that the vehicles in the three preferred categories number about 400,000, out of a

total of about 1.5 million in Canada. Thus well over a million motorists have not been permitted to buy tires or tubes. Late in 1943, however, with the advent of fair supplies of buna-S rubber, it became possible to provide more camelback for retreading, and rationing of retreading services came to an end.

Scrap and Reclaim Rubber

Canada has on hand enough scrap rubber to last two years. But unless the war is finally over by 1946 this will not be sufficient.

During the early years of the war, the scrap obtained by dealers and through the efforts of the National Salvage Committee was of high quality. But when reclaim rubber began appearing on the market in the form of tires, footwear and other articles, the scrap from these wartime products proved to be almost worthless. Thus it was necessary to gather as quickly as possible all the good quality scrap, and to stockpile it against the day when no more good scrap will remain hidden.

In 1941 a total of 22,179,755 pounds of reclaim rubber was used in Canada. The following year this rose to 32,694,000 pounds, and in 1943 approximately 30,000,000 pounds were used.

The measures of control over scrap and reclaim have closely paralleled those over crude rubber. On March 23, 1942, the use of reclaim was limited to much the same essential articles as those for which natural rubber could be used, but in many articles its use was made mandatory, and in other articles the manufacturers were compelled to use a specified proportion of reclaim.

When synthetic rubber became available, the restrictions on scrap and reclaim were gradually relaxed. Heels and soles may now be made of reclaim, and as a result much leather is being conserved.

Early in 1942, the government undertook a vigorous campaign to collect the scrap needed for reserves and to feed the two reclaim plants in Canada, one in Montreal and a smaller one in Toronto, and the United States reclaim plants which were then supplying 75 per cent of Canada's requirements.

The campaign was initiated by a separate Scrap Rubber Division of the Department, but later this division was merged with Fairmont Company. The activities of the division and of the Crown company brought out 25,000 tons of scrap to the end of 1943. The success of a similar campaign in the United States made it no longer necessary to ship scrap to U.S. reclaimers, and thus the Canadian collection found its way into huge stockpiles scattered all across the country. Present collections of scrap rubber are limited to tires and tubes.

Synthetic Rubber

The many chemical substitutes developed to take the place of natural rubber fall roughly into two categories: Vulcanizable synthetic rubbers such as buna-S, butyl and neoprene; and synthetic resins such as polyvinyl chlorides and polyvinyl acetates.

While both classes of materials are being used by rubber processors, the Rubber Control has assumed responsibility for the first group only, the second group coming under the jurisdiction of the Chemicals Control.

Technical research in rubber-like materials is continually progressing, and some day the perfect all-purpose synthetic rubber may be made. That day has not come, and in the meantime buna-S, butyl and neoprene are regarded as the three vulcanizable synthetics most closely resembling real rubber.

With this in mind, the North American program for developing synthetic rubber has centered around these three materials. As part of this over-all program, Canadian production in the government-owned Polymer Corporation plant is confined to buna-S and butyl rubber.

About the middle of 1943, supplies of buna-S, butyl, and neoprene, began to flow in from the United States. The importation of neoprene will continue indefinitely, but the importation of buna-S and butyl will cease early in 1944 when the Polymer plant is in full operation.

During the first few months the Canadian rubber processors employed the synthetic solely for experimental work. By August, 1943, much of this work had

been satisfactorily completed, and the Rubber Control ordered the substitution of buna-S in passenger and small truck tires, and a percentage use in large truck tires. Development of the use of buna-S in footwear, wire and cable, tire repair materials, and other items, has reached an advanced stage, and mandatory substitution is being made possible on an increasing scale.

Butyl rubber, to be used chiefly for inner tubes and life-rafts, has not yet been used in quantity in Canada. The United States experienced some initial difficulties in its manufacture, and the Canadian plant was not ready to produce it until the turn of the year.

The use of neoprene in Canada has been confined to oil-resistant belting, hose, gaskets, washers, and other items for which its properties make it most suitable. Supplies are obtained on U.S. allocations.

Production of a specialty type synthetic, known as thiokol, also is being undertaken in Canada by private interests. This synthetic is being used for certain types of hose, tire repair materials, and other articles.

As with natural rubber and reclaim, the Government-owned Fairmont Company Limited, with headquarters in Toronto, has a monopoly over trading in vulcanizable synthetic rubbers.

Polymer Corporation

Every man, woman, and child in Canada has a $4 stake in the government-owned Polymer Corporation synthetic rubber plant near Sarnia, Ontario.

Built at a cost of $48 million, which has represented hundreds of thousands of man-hours and tens of thousands of tons of scarce materials, this daring experiment is proving a success. Its products, buna-S and butyl, do not entirely replace natural rubber, yet they fill the wartime need so effectively that fears of a famine are over, and the armed forces are now assured of ample supplies.

In peacetime the rated plant capacity of 34,000 tons of buna-S and 4,000 tons of butyl would be sufficient to

meet all Canadian requirements, even after allowing for post-war expansion of industry and exports of finished rubber products.

The building of the vast plant has set something of a record for this country. Despite the severity of the winter of 1942-43, the 5,100 workmen and engineers engaged in its construction clipped three and a half months from the tight deadline set for them in 1942 by the Rubber Control.

The first tree on the 185-acre property was felled on June 10, 1942, but it was August 10, 1942, before the first sod was turned. Thirteen months and 19 days later, on September 29, 1943, using Canadian-made styrene and butadiene imported from the United States, commercial production of buna-S rubber began. It is expected that within the first few weeks of 1944 the plant will have been completed and in full operation.

In peacetime such a plant would have taken about three years to build. Under war pressure, it will have been completed within about a year and a half. To accomplish this feat, the engineers and other key men toiled seven days a week with a minimum of time for sleep. Hundreds of the workmen voluntarily reduced their lunch recess to half an hour, and all of them willingly put in long hours of overtime.

But the building of Polymer is remarkable not only for its speed, but also for its extent and complexity. To the layman, it does not mean much that the plant produces not only buna-S and butyl rubber, but also its own styrene, butadiene, and isobutylene, as well as its own steam and electric power. To the engineer and chemist, it means that Polymer has no counterpart anywhere in the world. Some plants produce butadiene without making buna-S, one makes butadiene and butyl, another makes styrene and butadiene, and still others make only styrene. The Polymer plant is unique in that it makes its own end ingredients as well as two types of synthetic rubber.

As an example of the complexity of the plant and its processes, it is pointed out that in one stage in the

making of one of the synthetic rubbers a temperature of 150 degrees F. below zero is required, and one second later this must be raised to 150 degrees F. above zero.

To make buna-S rubber calls for two chief ingredients, butadiene and styrene. The styrene unit at Polymer was rushed to completion within a year, and was producing commercially on July 14, 1943. The butadiene unit was not in operation until the turn of the year. Meanwhile, however, surplus styrene, not required until Polymer produces at capacity, has been shipped to the United States in exchange for butadiene, thus making possible the production of thousands of tons of buna-S in the summer and fall of 1943 that would not otherwise have been produced. This was at a time when rubber was urgently needed by the United Nations.

This exchange of basic ingredients was the result of a policy formulated early in 1942 by the governments of the two countries. Under this policy, high priorities were allowed on materials for rushing to completion the styrene unit in Canada and butadiene productive facilities in the United States.

At Sarnia butyl rubber is made from isobutylene produced at the plant. The production of butyl has been delayed because of the need for rushing the construction of the styrene and buna-S facilities.

Really the equivalent of a more or less self-contained village, the plant is in fact 10 big "factories," each as large and as complex as a good-size munitions plant. Bordering its 22 streets, it has its own hospital, fire hall, general store, bowling alley, post office, police department, cafeteria, and dining halls, one of which has also been used as a movie hall. It even has its own ball park and, in addition, has an administration building, laboratory, warehouse, machine shop, river dock, and railway siding.

Although the plant sprawls over the equivalent of 80 city blocks, only eight acres, or the equivalent of about three and a half city blocks, are covered with the permanent buildings. But connecting these buildings are six

miles of sewers, five miles of roads, 125 miles of medium and large steam, petroleum and water pipes, and countless miles of smaller pipes, electric cables, telephone wires, and robot control tubing.

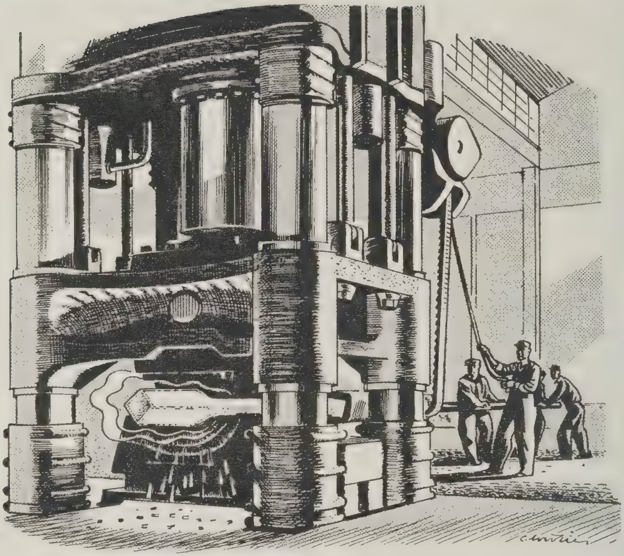
To transport the vast quantities of materials going into the project has required 8,900 freight cars, and to move these materials on the property and put them into position, approximately 40 tractors, 40 cranes, and 120 trucks have been in constant use.

Into the whole job have gone an estimated 5 million bricks, 102,700 cubic yards of concrete, 16.5 million board feet of lumber, 5,000 tons of reinforcing steel, 156,000 tons of crushed stone, 25,000 medium and large valves, and hundreds of thousands of nails, bolts, screws, and nuts.

To make its annual output of 38,000 long tons of synthetic rubber, Polymer annually requires approximately 500,000 tons of coal, more than 45 billion imperial gallons of water, 19 million imperial gallons of light ends petroleum, 2.5 billion cubic feet of petroleum gas, 2.25 million imperial gallons of benzol, and enough brine to contain 3,500 long tons of salt. In addition, great quantities of acids, soaps, and other raw materials are used.

When the last construction man has left the camp, it is estimated Polymer and its three operating companies will employ a total of about 1,250 men and 325 women.

The three operating companies are St. Clair Processing Company, a subsidiary of Imperial Oil; Dow Chemical Company of Canada Limited, a subsidiary of Dow Chemical Company of Midland, Michigan; and Canadian Synthetic Rubber Limited, a subsidiary of four Canadian rubber processing companies. Established at the instance of the Canadian government, the three companies operate the various units of the plant on a management-fee basis under the supervision of Polymer Corporation.



STEEL

EVERY time a Canadian-made gun blasts at an enemy position in Italy, or a Canadian destroyer fires at a U-boat, the chances are five to one that "Made in Canada" steel is being let loose at the enemy.

Prime sinew of war, steel is necessary for making, without a single exception, every mechanical contrivance of destruction. Even where it is not an ingredient, such as in plastic items, it is essential for discovering, carrying, and processing the raw materials, and for transporting the war supply to the fighting front. Without steel, war would still be waged with rocks and slings, bows and arrows, or hand to hand.

Thanks to careful planning, Canada's production of this vital commodity has been doubled since war began, and this country is now the fourth greatest steel producer

among the United Nations, exceeded only by the United States, the Union of Soviet Socialist Republics, and the United Kingdom.

Although steel was so scarce that for many critical months after the fall of France the whole Canadian war program was threatened, at no time has the lack of it caused a single, serious interruption of any phase of war production or service. At the close of 1943, with most large-scale construction projects completed, and with the rush of offensive preparations nearly over, more than enough was available to provide for war wastage, and certain types could be released to fill the gaps in civilian production. Sheet and strip steel, and malleable iron castings, were the only types of steel and iron in seriously short supply.

Canada has always been a heavy importer of steel from the United States and Britain. Early in the war the British sources were cut off, and the nation had to rely on the United States and its own resources. Despite an enormous rise in consumption, this country now depends on its southern neighbor for only about one-quarter of its supplies, instead of the pre-war ratio of one-third.

Because of the increased plant capacity, the new techniques, and the new experience which made this amazing achievement possible, Canada will be in a more independent position in the post-war world. The nation will face a quickening of its industrial pulse with a steel capacity capable of supplying enormous demands. It will be possible to ship building materials, automotive equipment, machinery, and other steel supplies to help in the reconstruction of the devastated areas of Europe and Asia. And also it will be possible, in due course, to fill the backlog of orders for automobiles, refrigerators, sewing machines, typewriters, and thousands of other Canadian civilian requirements.

Before the war, when a manufacturer wanted steel he ordered it to his own specifications. He demanded a steel made according to one of many thousands of compositions. If he sought strength he asked for an alloy

addition; if he wished for ductility he requested a double or triple alloy steel. To obtain various characteristics, he ordered a combination of various alloying metals in varying proportions and percentages. Whatever he wanted he got.

But with the advent of war, peacetime products vanished and in their place swiftly came steel for shells, guns, planes, armor plate, ships, and so forth. Because of the greatly increased tonnage requirements of alloy steels for armament purposes far beyond anything previously made in Canada, and necessitating the installation of new steel melting furnaces and auxiliary equipment, it became apparent that, temporarily at least, there would be a shortage of steel alloying elements such as nickel, manganese, chromium, vanadium, molybdenum, and tungsten.

The specifications for all war equipments had been developed in peace-time when all alloys were plentiful. But with an immensely expanded requirement the alloy tonnage did not add up. Carefully then the steel industry began to conserve the alloys, the scarce ones being used only in absolutely essential parts and others being lowered in scarce metal content. Quality did not suffer and the supply of alloys was made to go round. To accomplish this, co-operation was essential. Much alloy scrap steel of definite composition had to be kept separate and returned to the works which produced it, for remelting into similar types of steel, thus conserving the alloy elements.

The segregating of types of steel to single plants kept the number of steels to a minimum for each plant. This enabled small stocks to be carried and steel to be promptly put in circulation for processing.

Partly because of this conservation, the Canadian mills have been able to achieve spectacular expansion in the field of alloys for guns, armor plate, armor-piercing shot, airplane and tool steel. These types of steel call for great metallurgical skill, complex equipment, and the greatest number of man-hours. To begin, or to expand, production of such steels is as much more difficult as to

turn out a watch rather than a safety pin. Yet the output of Canadian alloy steels at the beginning of 1943 was five times as great as in 1939.

Before this war Canada had never manufactured a pound of armor plate. Today the quality of her product is so high, and the manufacturing process so skilful, that metallurgists from Britain and the United States have come to observe the operations. The one mill making this plate has turned out enough to load a mile-long freight train every month. This quantity took care of all Canadian requirements for this type of steel for tanks, armored vehicles, gunshields and for certain Canadian naval purposes.

Fortunately when the war began the Canadian steel mills had a sizeable unused capacity. In 1939 the Canadian production of steel ingots was under 1.5 million tons; in 1940 just over two million; in 1941 just over 2.5 million; and in 1942 and 1943 almost three million. In 1942 the ingot shortage was so serious that it was necessary to bring in nearly 100,000 tons of ordinary-size ingots from the United States, whereas before the war the only ingots imported were special order sizes or qualities. For example, to make the driving shaft of a ship might require an ingot larger than any produced in Canada.

For 1944 Canada will require more than three million product tons of steel of all kinds, and of this the United States mills will supply only about one-fifth. Last year the requirements totalled about the same, but the imports from the United States were more than one million. Plate production is up 400 per cent, steel castings up 240 per cent, and shell steel is being made at a rate of approximately 200,000 tons a year. More than 500,000 tons of steel per year are going into tanks and other military vehicles.

Despite the large increase in production, which now exceeds the average pre-war total of imports plus domestic output, the end of 1943 still saw shortages of end-products which affected every civilian. Late in the

year several forms of steel, including structural steels, were freed of restrictions, and larger quantities, subject to all war requirements first being met, were being made available for civilian purposes. Whether this relaxation could continue would depend on war developments and, in any case, the use of structural steels was still subject to the general restrictions on construction.

On September 1, 1939, total employment in the primary steel industry in Canada was 19,600. By October 1, 1942, it had reached 33,700, of whom 2,190 were women. Today's figures are approximately 35,900, of whom about 4,180 are women. Begun in 1942, the employment of women on the production side of this hitherto "man's game" is likely to continue throughout 1944.

The employment rise was most noticeable in Sault Ste. Marie, Ontario. This steel city normally has a population of a little more than 23,000. Today its population is 28,800. The influx of workers created a housing shortage so acute that it was necessary for the government-owned Wartime Housing Limited to erect 200 temporary dwellings to supplement the large number of new houses built privately in 1941 and 1942.

The expansion indicated by this rise in employment was not an easy task. It takes at least a year under peacetime conditions to erect a blast furnace. Whoever decides on such a venture must make certain that there is enough coke oven capacity, enough iron ore and limestone, and enough rolling capacity to handle the output of the open hearth furnaces which will convert into steel the pig iron from the new blast furnace. In wartime he must also consider whether or not the labor and materials to create the new blast furnace might be better employed at the fighting fronts.

With the object of producing "the greatest quantity of steel in the shortest possible time at the lowest possible cost," the government took advantage of existing facilities, trained staffs, and technical knowledge. Thus the expansion was confined to extensions of plants rather than the building of new plants.

The added facilities for boosting the production of pig iron and raw steel comprise five blast furnaces, nine electric furnaces, and five open hearth furnaces. A blast furnace capable of producing 1,000 tons a day was installed at Sault Ste. Marie, Ontario, where also a 300-ton-per-day blast furnace was rehabilitated, and 86 new coke ovens built. At the biggest plant in Canada, situated in Hamilton, Ontario, an 850-ton-per-day blast furnace was installed, a 150-ton open hearth furnace was completed shortly after the beginning of the war, and another 150-ton hearth furnace was built later. Also at this same Hamilton plant a new 65-ton electric furnace was constructed.

From Ojibway, Ontario, an unused 500-ton-per-day blast furnace was taken to Sydney, Nova Scotia, where it was rehabilitated and installed. Also at this Cape Breton plant two 100-ton open hearth furnaces were built. In addition, a 150-ton-per-day blast furnace was placed in a Port Colborne, Ontario, iron plant, and a 20-ton open hearth furnace in a Selkirk, Manitoba, plant.

Three electric furnaces, of 50, 30, and 1½-ton capacity, went into the second largest of the Hamilton plants, four 30-ton electric furnaces into a Welland, Ontario, plant, and a 3½-ton electric furnace into the Selkirk plant.

To round out the program, a 1,200-ton-per-day Bessemer furnace is being installed at the Sault plant.

These were the most important additions to Canadian steel plant capacity. But rolling and finishing capacities also were increased. Fortunately nearly two years before the war the big Hamilton plant had put into operation a new 3,000-ton-per-day blooming mill and, just before the outbreak of hostilities, had begun installing an 800-ton-per-day plate mill which started into production early in 1941. A 400-ton-per-day plate mill was rehabilitated at Sydney. A 2,500-ton-per-day blooming mill, and a 1,000-ton-per-day billet mill, were added to the Sault equipment, and a small billet mill, forging presses,

hammers, and other machines, to the Welland plant. Cold drawing equipment was installed at a drawn steel plant in Hamilton, and forging presses and other equipment at the second largest Hamilton plant.

It takes more than three and three quarters tons of raw materials to make a ton of pig iron: 1½ tons of coal to make a ton of coke, 1.8 tons of iron ore, and half a ton of limestone. The transportation of enormously increased quantities of raw materials presented a problem. To meet it, all available Great Lakes ships, both Canadian and American, were pooled, and as much space as possible was devoted to iron ore and coal. The total quantities thus carried in the past three years greatly exceeded those of any three years in the history of lake shipping. To speed up the turn-around of the ships, a third unloading bridge was built at Hamilton, and a fourth unloading ore bridge and a fourth unloading tower at Sault Ste. Marie. Thus the equivalent of two ships was added.

From the standpoint of tonnage, the most important use for Canada's war steel has been in shipbuilding. A 10,000-ton cargo vessel requires about 2,400 tons, in plates alone. The steel for such plates is an ordinary, good-grade commercial, mild carbon, such as that used in large petroleum or water tanks. The only production problem was to obtain quantity rather than particularly high quality.

In making the steel for guns, shells, tanks, or armored vehicles, the problem was more difficult. It involved both quality and quantity. Canada undertook to turn out armor plate ranging in thickness from one-eighth of an inch to about two and a half inches. Even the lightest of such plate must stop a bullet from a .303 machine gun, and is used extensively in shields for corvette and minesweeper gun crews. Intermediate thicknesses go into various fighting vehicles such as universal carriers, and the heaviest go into big tanks and armored cars.

Gun barrels, breech blocks, and other gun parts call for special alloy steels made in electric furnaces, which allow more accurate temperature control. Whereas gun or armor steels must be tough and hard, shell steel must

shatter evenly and in all directions. So shell steel is a medium carbon similar to that in an automobile crankshaft.

The manufacture of gun or armor steel is a touch-and-go task. The melt is an appropriate alloy, which calls for careful heating, tempering, and annealing, then reheating to make it less brittle, more shockproof. The Canadian technicians responsible for this steel did not depend only on the experience of steel makers in other countries. Even before the war they had worked out a few new tricks of their own. For example, they discovered that the old method of pouring ingots from the top of the mould caused too-sudden cooling and contraction in the top centre. Today they pour from the bottom, and at the same time burn straw on top of the mould. Notwithstanding this and other improvements in the process, the yield from this type is only fifty per cent.

Perhaps the most outstanding war contribution of the Canadian technicians in this field has been the perfection of a process for casting in one piece the upper hull and turret of a tank. This new process eliminates welding or rivetting, and produces a better, safer end-product. It also reduces costs and speeds up tank production. After exhaustive tests, the process was copied by the United States.

From a quantity standpoint, the foregoing types of steel are the most important in the war program. But the Canadian mills also had to turn out many other types, including tool steel, bullet core steel for small arms ammunition, and an anti-tank shot capable of piercing, at an angle of 30 degrees, an armor plate from two to three inches thick.

Iron has been smelted in Canada for more than 200 years, but it is only in the last forty years that the making of iron and steel has become a major industry in this country.

The City of Montreal was barely 28 years old before bog iron deposits were discovered along the St. Maurice River in what is now the Province of Quebec. In 1735,

the first smelting took place at Trois Rivières. Probably the first "war industry" in Canada, this Trois Rivières plant was established by the French settlers. It continued to operate until 1883.

Early in this century the Canadian steel industry boasted three integrated producers, in Hamilton and Sault Ste. Marie, Ontario, and Sydney, Nova Scotia. These three plants and a few smaller plants first achieved a total production of 100,000 tons in 1902. Fortunately for the Allied cause in the first Great War, this output had jumped above the million mark in 1913.

The war of 1914-18 spurred the industry to still greater achievements and prepared it for the bigger struggle that was to come. So great, indeed, was the output in 1918 that it was not surpassed until 1940.

Ore

Throughout its history, the Canadian steel industry has been handicapped not only by the comparative smallness of the home market, but also by a lack of adequate domestic iron ore, and in Ontario a lack of the necessary coal for making coke.

From 1923 to 1939 Canada produced no recorded output of iron ore. In 1937 the rebuilding of surface equipment was started at the Helen mine in the Michipicoten district of Ontario. The ore from this mine is an iron carbonate with a low iron content (approximately 36 per cent), and rather high in sulphur. It requires sintering, a form of roasting, before it can be used in a blast furnace. Assisted by an Ontario government subsidy promised for ten years from January 1, 1939, and on the basis of two cents per unit of iron content, the operations got under way in 1939, in time to be of value in the war program. Development work also has started on an iron ore body at Steep Rock Lake in northwestern Ontario.

Except for these two sources, existing and potential, and a mine in New Brunswick, Canada has to depend on imports. All the Canadian steel companies operating blast furnaces either own their own mines, possess a part interest, or have long-term contracts with the producers.

Although record imports have been required, the Lake Superior ore fields have been able to meet Canadian demands. The blast furnaces at Hamilton, and the plants at the Sault and Port Colborne, secure their supplies from this source except that the Sault also receives iron ore from its own Helen mine. Their only difficulty has been a shortage of unloading facilities and it was for this reason that the large Hamilton plant built an additional ore bridge at that Lake Ontario port, and an additional ore bridge was built at the Sault.

The Sault company produces annually from 450,000 to 475,000 tons of ore at its Michipicoten mine, and exports about half this amount to the United States in exchange for U.S. Lake Superior ores of required qualities.

The Sydney mill obtains its blast furnace ore from Newfoundland, and in peacetime brings in for open hearth use a high-grade ore from Brazil. When shipping difficulties made it impossible to continue the importations from South America, arrangements were made to obtain a suitable open hearth ore from the United States.

The shipments from Newfoundland across the Gulf of St. Lawrence were exposed to Nazi U-boats, and several vessels were sunk. To offset this loss, a deposit in Bathurst County, New Brunswick, with a proven ore body of 600,000 tons, was re-opened after being in disuse for many years. To bring out the ore from this mine, 17 miles of railway owned by the New Brunswick government and operated by the Canadian National Railways, were rehabilitated at a cost to the Dominion government of roughly $100,000.

One of the biggest iron ore developments in Canadian history has been that at Steep Rock Lake, which is about 150 miles west of Port Arthur, Ontario. The existence of the ore has been known for some time but it required the impetus of a war emergency to bring about its development. The undertaking is being financed privately. The Dominion government has granted a subsidy of 20 cents a ton on the movement of five million tons of ore. The Canadian National Railways is building an

ore dock and the trackage required for the undertaking. The project, which is costing a total of about $20 million, involves the draining of Steep Rock Lake and the exposing of several bodies of high-grade hematite.

Such an engineering feat is not as simple as it sounds. To make it possible the entire appearance of the immediate district had to be changed. One small lake was made to disappear, another was completely emptied, the course of a river was reversed and, as a climax, billions of gallons of water were channeled into a new river where there had never been a river before.

Close by and draining into Steep Rock Lake was Moose Lake. Above these was Finlayson Lake, twelve miles long and covering an area of ten square miles. The engineers lowered the level of Finlayson Lake by driving a 1,600-foot rock tunnel, or man-made "drain-pipe," into the bed. They then diverted the waters of Moose Lake into Finlayson, thus halting the flow of water into Steep Rock. Thereafter, it was a comparatively simple matter to begin draining Steep Rock and exposing the hematite, estimated at 50 million tons of which 20 million tons is said to contain 60 per cent iron.

Pumping started early in December, 1943, and it was expected that it will be May, 1944, before the ore comes in sight and August, 1944, before open-pit mining of the peak points can be started. The annual output will be in the neighborhood of two million tons, but only about half a million will be mined in 1944. Much of the initial production will help feed the war industries of the United States.

Coke

With one minor exception, all the blast furnace operators in Canada also have their own coke ovens. The exception is the small iron plant at Port Colborne, which depends on United States sources.

The coking capacity at Sault Ste. Marie for many years was in excess of requirements and that excess filled the total coke consumption of the nickel smelters in the Sudbury district. When an additional blast furnace

at Sault Ste. Marie was rehabilitated in June, 1942, additional coke was needed. To meet this demand, a Montreal coke company discontinued supplying householders, and shipped much of its coke to the nickel smelter at Coniston, Ontario, and later to the pig iron plant at Port Colborne; some of the coke from the United States which ordinarily filled the Port Colborne needs being diverted to the Sault.

By the middle of 1943, however, a battery of 86 new coke ovens had been installed at the Sault and in addition to meeting the requirements of its own furnaces and of the nickel smelters the Sault plant produced a large tonnage of domestic coke, and the pressure on the Montreal coke company was relieved. The additional coke thus made available helped to relieve the fuel shortage in Ontario and Quebec.

Coke ovens were erected at Hamilton to supply gas for the district. The coke was not suitable for blast furnace use.

Pig Iron

Pig iron is produced in a blast furnace to diverse analyses. It is used with scrap in producing steel in open hearth furnaces, or by the foundries in producing ordinary gray iron or malleable castings.

The "Big Three" steel companies—the biggest of the Hamilton plants and the plants at Sault Ste. Marie and Sydney—operate blast furnaces and produce basic iron for use in their own open hearth furnaces. Under ordinary circumstances, the Hamilton and Sault plants also make foundry and malleable iron for the commercial market. The Port Colborne plant makes iron exclusively for sale to the foundries.

Because of the heavy war demands for steel, the Hamilton and Sault plants were found to be producing basic iron for their own, rather than foundry use. As a result the foundries, which had on hand important war contracts to turn out castings, were running short of iron. In June, 1941, Steel Control arranged that the Hamilton plant should devote its blast furnace capacity

to basic iron, that the Sault should produce the required foundry iron, and that Port Colborne should be responsible for malleable iron.

During the last few months of 1943, the pig iron position eased somewhat, and it was possible to permit the Sault plant also to produce some foundry iron, and the largest of the Hamilton plants to produce both foundry and malleable grades.

Since the beginning of the war the blast furnace capacity of this country has been greatly increased. The five new blast furnaces are able to produce 2,800 tons a day.

To feed one of the five new furnaces, the 1,000-ton-per-day blast furnace at the Sault, 86 new coke ovens were installed with a combined capacity for handling 2,000 tons of coal per day. The coke ovens went into operation on July 1, 1943, and the furnace was ready by the middle of August. The lighting of the furnace was deferred until November 29, and the older furnaces were blown out at that time, so that as much coke as possible could be supplied to householders in the Toronto area.

Pig iron production in Canada during the past three years has been roughly double what it was in 1939. The output in gross tons has been:

	Basic Iron	Foundry	Malleable	Special
1939	655,560	71,709	28,462	...
1940	974,629	107,924	86,287	...
1941	1,135,516	98,101	123,113	14,446
1942	1,469,579	137,654	151,105	14,999
1943	1,300,495	132,720	136,667	10,168

To meet a shortage of cast iron scrap in British Columbia, arrangements were made by a Dominion government agency, Wartime Salvage Limited, to bring in foundry pig iron from Ironton, Utah. In March, 1943, about 1,000 tons were imported, but before the year was over the monthly total was less than half this figure.

Steel Bars

Although in great demand today for essential civilian manufacture, as well as for direct war purposes, steel in bar form is in a somewhat easier supply position.

Steel in bar form represents about one-quarter of the output of the Canadian mills. It is rolled in rounds, squares, flats, angles, and suchlike, in a wide range of qualities and sizes for a multitude of articles ranging from small shells to tank axles, universal carrier frames to ship bolts, horseshoes to washing machine legs, axes to tractor pistons.

Individual orders from the manufacturers are usually in much smaller quantities than for plate or heavy structural steels, and the number of such orders runs into the thousands. To enable the mill to fill all the varied demands, rolling schedules are arranged in cycles, commencing with the largest sizes and ending with the smallest. The orders are grouped by sizes to avoid frequent roll changes, and thus provide sufficient tonnage on each rolling for economical operation.

In the early days of the war program, the mills had a congestion of orders, and were constantly faced with decisions as to whether or not rolling schedules should be dislocated to allow for "high priority" special orders brought to the mill by war production expediters. When Steel Control took over the responsibility for deciding which orders should be given preference, the day-to-day problems of the operators became lighter. A plan eventually was worked out under which steel purchasers were required to submit their orders to the Control. Any orders approved as to essentiality were forwarded to the mill with a directive as to time of rolling. From the directives the mills arranged their monthly rolling schedules, which they submitted to the Steel Control for final approval. The Control officers handling this work had accurate knowledge of each mill's capacity, and the tendency was to overload the schedule for each mill with bona fide war orders, and thus squeeze out non-essential production. This control at the source was eventually applied to all types of steel.

To assist the farmers in providing more foodstuffs for Britain and for the armed services, great emphasis was placed last year on the production of steel bars for agricultural implements. In 1942 the manufacturers of such implements were on a quota of 25 per cent of the

steel used for new farm machines in 1940, and 150 per cent for repair parts. For the 1943 and 1944 programs more steel was asked and approved.

From the beginning of the war until the summer of 1943, bars were in short supply. This was not only because of the great demand, but also because enough raw steel could not be spared from the production of other war steels, such as plate. When some war programs were curtailed the position eased. More billet steel could be used for making bars, and fewer bars were needed for bolts, rivets, and other requirements.

Structural Steel

The larger structural steels, known as the "big bones of the building industry," are produced in Canada only at Sault Ste. Marie. With the fall of France, and the consequent sudden call for added war plant facilities, the demand on this mill exceeded its capacity. This demand continued at a high level until toward the close of 1942, when it again became possible to allow the railways greater quantities of rails.

A few days after Pearl Harbor, the Steel Control placed the sale and use of heavy structural steels on a permit basis. In addition, the non-essential use of such steels was curbed by the Construction Control, which refused to grant a licence to construct any large unnecessary building or plant, or to install non-essential machinery.

Plates

Steel plates are the tough hides of destroyers, minesweepers, corvettes, cargo ships, tanks, armored cars, and gun crew shields.

At the outbreak of war only one large plate mill was operating in Canada. Second largest steel mill in Hamilton, it produced plate to a maximum width of 78 inches, and from time to time was changed over to the production of hot steel strip for tinplate. The largest Canadian steel company, also in Hamilton, was in the process of erecting a plate mill with a practical

width capacity of 100 inches, as the first stage of a continuous sheet mill. This plate mill came into operation in April, 1941. A steel company at Trenton, Nova Scotia, also boasted a small plate mill capable of turning out narrow plate up to about 48 inches.

At Sydney a plate mill was installed during the war of 1914-18, but had been in disuse and was largely dismantled. This mill was rehabilitated and went into operation in April, 1942.

The demand for plate began rising sharply in the second half of 1941, when the shipbuilding facilities of the Dominion, developed after 1939, swung into production. The supply of plate soon proved insufficient, and matters were made worse when the older and smaller of the Hamilton plate mills undertook to make armor plate. Such plate required more careful rolling, and the mills' output was cut in half.

The United States was in short supply, and the only answer was to increase Canadian production. The largest Hamilton plate mill was already producing about 13,000 tons a month on a two-shift basis. Pressure was exerted on the company to train a third shift, and the output rose to about 20,000 tons.

To keep the three shifts going took great quantities of raw steel. The company did not have enough, unless its shipments to its own bar mill in Montreal were eliminated. The Steel Control arranged that 5,000 tons a month of billets should be shipped from Sydney to Montreal. When the plate mill at Sydney went into operation, the Sault plant made up the deficit.

The plate mill at Sydney operated at first on only one shift. Later this was increased to two shifts.

So long as the acute shortage lasted, no plate, other than ends and large shearings, was released for any but the most essential purposes. Imports from the United States, which continued high until the last few weeks of 1943, were all channeled into high priority uses.

Wire and Wire Products

In 1942 at the peak of the steel shortage nails were being used at an annual rate of 100,000 tons, or enough in terms of raw steel to supply all the needs of the Canadian gun program. Until April of that year civilian demands for wire steel in the form of nails, barbed wire, hay wire, baling wire, and other kinds of wire steel, had been met from inventories. Comparatively little of such steel had been needed for war purposes other than for military and prisoners' camp fencing, for packaging wire, and for a special type of barbed wire known as concertina. But when the demands suddenly rose, it became impossible to allot sufficient raw steel to make the required wire steel. Quotas were imposed on the wire steel mills, and sales were limited to not over 500 pounds, except by approval of the Steel Control. Special demands, such as the need for nails for building the storage facilities to hold the bumper western grain crop, and the requirements of Wartime Housing Limited, were taken care of outside the quota.

Flat steel strapping, used for reinforcing packages and crates, is normally competitive with wire for the same purpose. Not made in Canada, it is imported from the United States, and when that country imposed restrictions on its use, similar restrictions were applied in this country.

Castings

The chief producers of steel castings for war purposes have been the larger foundries, but some small foundries have played an important part in turning out essential items.

A motor car company and four large foundries expanded their casting facilities and thus eased a capacity shortage which developed when peak war production was achieved. Being largely repetitive, the schedules of the foundries needed little supervision from Steel Control. Approvals were required only for new lines.

Grey iron castings are in very small demand for war purposes. The capacity in Canada has been sufficient

to meet all essential needs, provided only that sufficient pig iron and cast iron scrap were available. Control over the foundries has been achieved by supervision of their consumption of these two raw materials.

The production of malleable castings for war purposes has been under the direction of a committee working with the Co-ordinator of Production, and the Steel Control.

Atlas Plant Extension Limited

Mere production figures do not tell the story of Canadian steel-making in this war. The most amazing achievements have been in quality rather than quantity.

To nearly treble the capacity of Canadian industry, as has been done since the outbreak of hostilities, machine tools of all kinds were needed. Enough such tools could not be obtained from outside sources, and it became necessary not only to make the tools in this country, but also to make the high-grade alloy steels from which the tools are manufactured. It was also necessary to develop quickly new facilities for making other fine steels for guns, aircraft, and other war equipment.

To obtain such steels, the government decided to build a new plant adjoining and forming an integral part of a company already specializing in high quality products. The choice, for many reasons, was the plant of Atlas Steels Limited in Welland, Ontario, which before the war was turning out high-speed alloy and carbon steels, stainless steels, and other alloys.

The necessary plant expansion and new types of equipment were quickly decided upon, and a Crown company established in October, 1940, to supervise the construction and operation of the extension. In the short space of 19 months the new plant was built, equipment installed, and further staff trained to put the whole unit into operation by September, 1942. This was accomplished under the stress of maintaining capacity output from the existing plant. As each section of the new unit was installed, it went into production whether there was a roof over it or not.

The training of personnel was a major problem. Melting and rolling crews, and all the necessary component crews, were divided, and half were put on the new equipment as it was installed. The skeleton crews in both the old and the new plants were able to keep up operation at the same time as they trained in new staffs. For the first time in the history of the company, women were hired for mill work. They are employed as crane operators, machinists, chemists, inspectors, shippers, metallurgical observers, and in other capacities.

The first gun barrel contract was placed with the private company on January 19, 1940, about nine months before there was any question of a plant extension being built. Today all types of barrels are being shipped from the extended plant on the basis of a 7,000 per cent increase over that original contract. The same phenomenal increases have applied to the production of steels for Bren, Boys, and Browning guns, and other small arms.

In the form of bars, rods or forgings, the plant supplies the manufacturers with steel for tools, dies, gauges, and parts for aircraft, tanks, gun carriages, guns, motor torpedo boats, destroyers, minesweepers, corvettes, automotive equipment, and railway equipment. Special steels from this plant have been sent to the United States, the United Kingdom, Australia, New Zealand, South Africa, and India.

The original Atlas plant had two small furnaces, a 10-ton and a five-ton. Two 30-ton furnaces were authorized for the enlarged plant, as well as forging hammers, presses, and other equipment. Later two additional 30-ton furnaces were installed.

United States Imports

In peace as well as in war, Canada has always depended on outside sources for a substantial proportion of her needs. The limited domestic market has made it uneconomical to install the equipment for turning out many forms rolled in the United States.

Before the war substantial quantities were brought in from the United Kingdom. When this source was cut

off, the United States promised to make up the deficit rather than oblige its northern neighbor to carry out undue expansion of steel-making capacity.

In the early days of the war, when the Canadian manufacturer could not obtain his requirements from the domestic producers, he was told to order from the United States. However, when that nation's preparedness program got into swing this access to U.S. sources became more difficult. Early in 1941, preference ratings were established by Washington, and the principle was recognized, under the terms of the Hyde Park agreement, that Canadian purchasers would receive the same concessions as American purchasers.

To determine what orders should be filled and which of these should get a priority, and later to determine the complex degrees of priority, became one of the worst headaches of the whole war effort. The Canadian Steel Control was drawn into a vortex of orders and amendments to orders, and generally speaking was given the task of determining the steel import requirements, of allocating the imports, and of policing the users to prevent misuse.

By restricting civilian use of steel to the barest minimum, the Canadian war program was maintained despite the rising demand.

Under the system of priorities in operation at the close of 1943, the Canadian buyer of American steel in mill form was relieved of the onus of proving to the U.S. preference allocators that he must have the steel. Instead, the Canadian Steel Control obtained a national allotment, and arranged all the formalities for the buyer.

Imports of steel from the United States rose from 402,294 tons in 1939 to more than 1.58 million tons in 1942. The figure for last year fell to just over one million.

Scrap Iron and Steel

It takes steel to make steel. Except in a Bessemer furnace, it is impracticable to make steel from pig iron alone. A proportion of scrap steel is essential.

As yet Canada has no Bessemer furnace, although one is being installed at Sault Ste. Marie. This Bessemer at the Sault is not intended for making Bessemer steel, although it could do so. Instead it is designed to turn out a so-called "synthetic" scrap, which is a semi-processed pig iron, from which much of the carbon has been removed. This "synthetic" scrap, mixed with molten iron, can be melted in an open hearth furnace to make ingots.

Scrap iron is used with pig iron to make iron castings.

The Canadian war program has called for many millions of tons of scrap iron and steel. As between mills, the ratio of scrap steel as against pig iron in the melting varies greatly, depending to some extent on the availability of scrap. For example, the Sydney plant in 1940 was using 70 per cent pig iron and 30 per cent scrap, while the largest of the Hamilton plants was employing 40 per cent pig iron, 60 per cent scrap. Because pig iron is not suitable for high quality steels, the electric furnace operations call for almost 100 per cent scrap.

The pig iron supply can be increased by the erection of blast furnaces, but such furnaces cannot be built in a day. The scrap supply can be increased only by going after existing waste and discarded steel articles, many of which are to be found only in out-of-the-way places. The collection of scrap is a job for experts, although the initial gathering of household and farm articles in comparatively small tonnages became the patriotic endeavor of many charitable organizations welded together into local committees under the leadership of a government agency, the National War Salvage Committee.

With steel prices frozen, the matter of scrap prices received early attention. In February, 1941, the Steel Control fixed prices for steel scrap which allowed the dealer approximately $3 per gross ton for sorting, cutting, and handling. The freezing of prices on cast iron scrap was deferred until the W.P.T.B. general price freezing order went into effect on December 1, 1941.

As a result of the activities of the scrap division of Steel Control, of the government's scrap buying agency,

Wartime Salvage Limited, of the National War Salvage Committee, and of many thousands of individual Canadians, working singly or in associations of various kinds, enough scrap was gathered to keep the furnaces going at full blast. Apart from price orders, the only mandatory order found necessary was passed in July, 1942. Under this order it became illegal to retain any article, commodity, or material, which could be used as iron or steel scrap, and which was not serving an immediate useful purpose. As an incidental to the application of the order, the Steel Control discovered some idle machinery which became available for essential manufacture.

Although the United States also was short of scrap, the government of that country treated Canada very generously. Hundreds of thousands of tons have been brought in, and in return Canada has shipped to the United States substantial quantities of types of scrap not suitable for use in this country, and of ordinary scrap to western U.S. points.

Steel Control

In the fateful days of the spring and early summer of 1940, things moved fast. Norway, Denmark, Luxembourg, the Netherlands, Belgium, and then France, fell to the enemy in rapid succession. Alone, England prepared to withstand the threatened invasion, and if need be to carry on the war from Canada.

Anxious and full of uncertainties, this country sprang into quick action. Within a matter of days, additional plans were drafted for great new industrial facilities. Factories were to be built. Power plants expanded. Base metal mining stepped up. The whole tempo of Canadian life was to be accelerated.

All the plans called for steel. Great quantities would be needed. So on June 24, 1940, two days after Hitler signed an armistice with the French generals, the Department of Munitions and Supply, already a lusty infant, launched the Steel Control, and appointed the first of two officers who have held the post of Controller.

Before the Controller had more than time to find himself an office, a deluge of problems demanded immediate

solution. The Minister called together the primary steel producers on July 4, 1940, introduced the Controller, and elicited a promise of full co-operation in boosting production and in maintaining existing price levels.

It was still too early to know how much, and what kinds of steel would be needed to build and feed the giant new industries for which the blueprints were being drafted. But much war material already was being made in the factories which had been adaptable to a quick change-over, and the Control was kept busy during the first year of its existence at the task of expediting deliveries to war contractors.

As the purchase orders at the mills continued to pile up, it soon became obvious that the iron and steel capacity of this country was inadequate to meet the demands. Even though the United States was helping by increasing steel exports, it was found advisable to expand Canadian facilities, and to reduce civilian consumption.

From the very beginning conservation has been achieved largely by control at the source. The rolling schedules at the mills have been supervised in such a way that non-essential orders have been squeezed out. In addition, however, hundreds of thousands of tons of steel have been saved by voluntary and mandatory substitution of less scarce materials, and this has been possible in war, as well as civilian, manufacture.

The Commonwealth Air Training Plan at that time called for 52 hangars, or about one-seventh of the number eventually built. Timber had not yet become scarce, and it was arranged with the Timber Control that 26 of these initial hangars would be made of wood and the other 26 of steel.

Later, in co-operation with the Construction Control and the Construction Branch, the use of substitutes, including concrete and wood, was ordered wherever possible in the building of all government structures. To extend this policy to cover civilian construction, an order was issued on December 18, 1941, which prohibited the use of structural and reinforcing steel except under a Steel Control permit, and a section of the Control was

set up to administer the order. This section, working in close collaboration with the Construction Control, studied all building plans with a view to approving or rejecting the application for steel. It prevented the padding of purchase orders, and arranged, wherever possible, for the substitution of materials in more plentiful supply. For example, it refused permits for steel for building fire escapes, window lintels, and for other construction purposes which could be temporarily postponed.

Since the middle of 1942, lumber has been in short supply, and the Construction Control has found it necessary to eliminate all non-essential building. This in turn helped the steel situation.

In the latter half of 1940, the meat packing industry was persuaded to use wood or fibre board instead of tin containers for packaging lard or shortening. Other distributors followed suit and many articles, including the flat boxes of 50 cigarettes, were no longer sold in tin containers. Later, at the instance of the Metals Control, the Wartime Prices and Trade Board banned the use of tinplate for packaging a long list of consumer items, including many foodstuffs.

Steel culverts came under a ban early in 1942. To make such culverts calls for a heavy gauge, usually copper-bearing steel, whereas wood or concrete will serve in most instances equally well.

When the Canadian processors of non-essential items, such as metal toys, sporting goods, or steel filing cabinets, found they could not obtain Canadian steel, they tried to obtain their supplies from the United States. At first they were successful in this, but after the first U.S. regulations went into effect in 1941, their supply source dried up.

Much steel was saved by the Department through orders of Controls other than the Steel Control. The Supplies Control, which until early in 1942 had jurisdiction over scores of end-products, banned or restricted production of a long list of articles, including washing machines, radios, stoves, beds, metal toys, refrigerators, metal office furniture and equipment, roller skates, ice

skates, and some metal kitchen gadgets. By the beginning of April, 1942, the production of passenger automobiles had been stopped by the Motor Vehicle Control, and the output of civilian trucks and buses was drastically curtailed.

In addition, the Wartime Prices and Trade Board cut out the frills of civilian manufacture and, by new and simpler standardized designs for essential articles, saved much steel. The same body kept at a bare minimum the manufacture of farm implements until steel came to be in better supply. Early in 1942, it took over the control of the metal end-products formerly under the jurisdiction of the Supplies Control, and it thereafter continued the policy of eliminating the manufacture of non-essentials and curtailing the output of many essentials.

Except for the order, passed in December, 1941, which placed on a permit basis the sale or use of steel plates, structural shapes, or bars, for construction work, most of the initial orders of the Steel Control dealt with scrap prices.

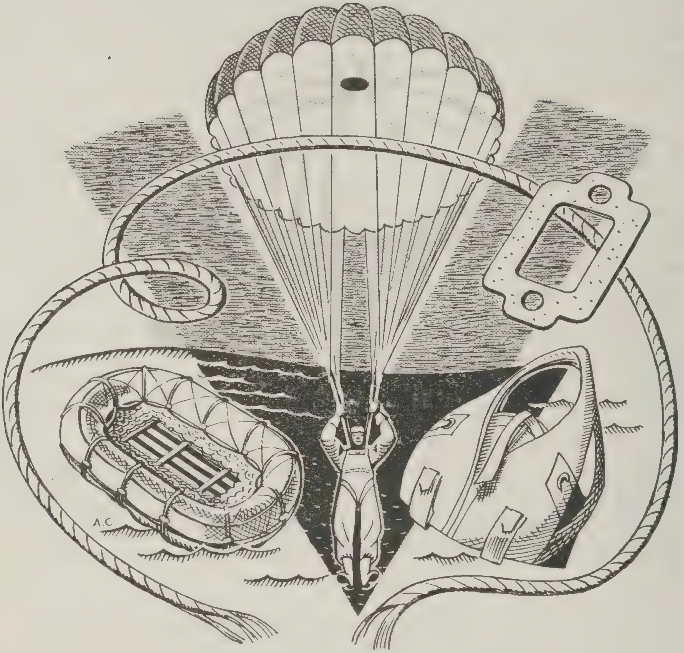
Already restricted by the supervision exercised over rolling schedules, most of the types of steel were formally regulated by a series of orders issued from March to September, 1942. In March the Control cancelled all but a few unfilled purchase orders for bars and structural shapes, which orders had been in the hands of the mills before December 1, 1941.

Three years of war expenditures were reflected in improved civic finances in many municipalities, and a demand arose for great quantities of cast iron pipe for extending water and gas mains. Likewise, steel pipe was in demand for many purposes, including the installation of sprinkler systems. But cast iron pipe was needed for more urgent war purposes, and because the U.S. Bessemer skelp for steel pipes was in short supply, both these types of iron and steel had to be restricted. The more or less informal regulations already in force were replaced in July, 1942, by an order which put the sale and use of cast iron pipe on a permit basis. In September,

1942, steel pipe also was formally controlled. Late in 1943 restrictions over both cast and steel pipe were rescinded.

In August, 1942, a consolidation of the directives regarding structural shapes and bars was issued, and in the same month another consolidation affected plates, sheets, and forgings. Also in August stainless steel came under a formal permit system. In October the variety of wire nails was limited, and in November the structural steel order was made more severe. One year later this structural steel order was cancelled.

The following year, 1943, saw three new restrictions of importance. To conserve zinc and to conserve steel sheet, an order in May, 1943, limited the sale and use of steel roofing sheet. In August the wire rope makers were ordered to produce fewer and simpler, standardized types and, at about the same time, sales of wire steel for making nails, hay wire, and other wire items, were limited to 500 pounds ex-permit. Steps were taken late in the year to rescind this wire order.



SUPPLIES

A CLUSTER of parachutes drifts slowly to the ground. Below, guerilla forces eagerly await the reinforcements and supplies to continue their fight against the hated invader.

The dread cry of "Abandon Ship" rings through the night and crew members take to the cold, dark waters, secure in the knowledge that their lifebelts will keep them afloat until rescued.

There is silk for those parachutes, kapok for those lifebelts, because these vital materials were stockpiled early in the war and held for essential war needs, none being released for civilian use in more than two years.

Although European aspects of the war have occupied the greater part of Canada's attention, the potential global aspects of the struggle were apparent as far back as 1939. It was evident, for instance, that certain basic war materials from the Far East—rubber, silk, kapok, and hemp—would be in short supply.

To prepare for possible shortages, these materials were stockpiled in Canada and held for government account. In August, 1941, a Controller of Supplies was appointed to regulate the production, sale, distribution, and use of any commodity declared by the Minister to be a "supply," and by the end of the year restrictions had been imposed on rubber, silk, kapok, hemp, and cork.

But these were not the only commodities made scarce by wartime conditions. Steel, too, was in short supply, and many manufactured items using this and other critical materials were declared to be "supplies" and thus brought under the direct jurisdiction of the Controller.

Historical

The first few months were hectic in the life of the Supplies Control. Scarcely a day went by without its being found necessary to issue a new order. By the end of 1942, more than a hundred different manufactured products, including bicycles, metal furniture for homes and offices, radios, stoves, and refrigerators, had been declared "supplies."

The story of how restrictions were placed on the manufacture of radios is indicative of the speed with which the Controller's office worked. On October 1, 1941, the Minister declared radios to be "supplies," and the same day their production was limited to 75 per cent of the 1940 output. Further reductions followed, and by December their production was cut in half. Early in the New Year, radio replacement parts were put on the supply list, and by January 8, 1942, an order was issued prohibiting all radio manufacture.

When Canada declared war on Japan, the Supplies Control office took on greater importance, necessitating a change in emphasis. A Deputy Controller, whose sole

concern was rubber, was appointed. Two other Deputies were appointed to administer the supplies of other Far Eastern commodities under the Controller's jurisdiction.

By this time, the Wartime Prices and Trade Board was taking an increasingly important part in the administration of metal consumer products, and it was decided that all Supplies Control metal items should be transferred to that Board.

Rubber

Most critical of all supplies was rubber. Although all stocks of processed and crude rubber were frozen a few days after Canada declared war on Japan, it was evident that only by the strictest conservation could the available supplies be stretched to meet war demands. By the middle of 1942, the rubber shortage was so severe and its control so complicated that a separate control was organized to deal with it.

Silk

Silk stockings were one of the first wartime civilian casualties when raw silk was declared a "supply" in August, 1941. Stocks already in Canada, plus a few hundred bales obtained in the United States, had to be eked out to meet the demand for parachutes for the armed forces.

Plateau Company Limited, a government-owned agency, which had been set up the previous year to acquire, store, and distribute war materials, took over the distribution of raw silk.

The company undertook to gather up all the raw silk on hand in Canadian mills, and to negotiate with the Office of Production Management in Washington for the delivery of silk contracts owned by Canadian mills. In this way, sufficient silk was acquired by the company to cover essential war needs until nylon production was underway.

Now that nylon is being produced, the silk situation has eased and what remains of the stockpile is ample for 1944 needs. It will be used only for repairing parachutes and, to a lesser extent, for insulation fabrics for certain electrical equipment.

Nylon

The most satisfactory of silk substitutes, nylon is now being produced in large enough quantities to supply the needs of the Canadian armed forces and to ship 160,000 pounds of yarn each month to the British Ministry of Aircraft Production.

The Kingston plant of Canadian Industries Limited was completed early in 1942. Before the end of the year nylon yarn was being produced in commercial quantities in Canada for the first time. In little more than a year, the plant has produced and shipped to England more than 1.8 million pounds of parachute yarn.

Since its inception, the plant's entire production has been devoted to war orders. The yarn is used to make parachute cloth and parachute shroud lines, but other uses for the yarn are being developed.

Kapok

In peacetime, large quantities of kapok were used as stuffing for cushions. In wartime, it is vitally needed to save the lives of seamen, for kapok has great buoyancy and is water-resistant. It is ideal for filling life-saving equipment.

The best quality kapok is grown in Java, and when Japan occupied the Dutch East Indies, supplies were cut off. On the Controller's order, all available stocks in Canada were frozen for use in life-saving equipment, but when these were used up, the situation became critical. However, additional supplies were obtained from the United States, and shipments of suitable Indian kapok are now being delivered. Present stocks are expected to meet requirements until mid-summer of 1944.

Cork

Allied victories in North Africa have been directly responsible for the lifting of restrictions on the use of cork board. In short supply from September, 1941, cork was under strict control for more than a year until cork-producing territory in North Africa was liberated.

Hemp

Before the war, the British Navy put to sea with rope made from Italian hemp. The United States and Canada imported Manila hemp from the Philippines. The war in two hemispheres cut off supplies, and all three countries had to depend on their own stockpiles of these hard fibres. They are the best fibres capable of resisting sea water.

At the end of 1942, it was apparent that the over-all supply would be inadequate and supplies were then pooled between Britain, the United States, and Canada.

With all stocks of Manila hemp restricted to the making of rope for the Navy and Merchant Navy, rope makers turned to sisal as a substitute. This in turn became scarce, and late in December, 1942, the manufacture of all tying twines, except binder twine made from sisal, was prohibited. Economies in binder twine production were also made.

Today, for the first time in two years, the hard fibre supply picture is brighter. There are two reasons for this. The growing of hemp in the United States, and of other fibres in other countries, has increased to such a point that allocations made to Canada for 1944 are expected to be adequate for all our requirements. The other reason is military. With the Allied invasion of Italy, stores of Italian hemp are expected to be available to Britain as soon as the situation becomes clarified and organized.

TIMBER

HISTORY is turning a full circle. Once again civilization is on the threshold of an Age of Wood.

Taken for granted at the outbreak of war, wood has always been looked upon by Canadians as a plentiful raw material, rather old-fashioned but useful for such things as barn doors, porridge ladles, or newsprint. Today, it is no longer plentiful in relation to the demand. Its war uses are legion. Its prime importance in the post-war world is assured.

Under the wand of the plastics chemist, wood now becomes anything from a bullet-resistant windshield to a rayon parachute, a shell nose, a machine gun drum, or perhaps a sponge. In peacetime, it will become fire-resistant wallboard, an automobile part, or any one of thousands of articles.

As plywood, it is being shaped into the body of a speedy Mosquito bomber, a motor torpedo boat, or an invasion barge. When the war is over, such wood may be used for gasoline cans, hand luggage, automobile body parts, book covers, furniture, fluorescent lighting troughs, refrigerator shells, culverts, moulded walls, lifeboats, and myriad other items.

As nitrocellulose, it is taking the place of cotton for making high explosives, and is likely to do so even after the war. As paper, it fills the tip of a bullet. And in its natural state, thanks to a new technique, it is proving itself a rival of steel in large-scale construction.

More prosaically, but in greater quantities, it is packing universal carriers, tanks, shells, and other war supplies. It is propping up British, as well as Canadian, mine shafts. It is forming beds of ties for the rail movement of an unprecedented flow of war materials. It has gone into the construction of enough hangars to fit into a single such structure 112 feet wide and more than 30 miles long. It has been used in the construction of hundreds of barracks, docks, wartime houses, and other war buildings. It is replacing steel in more than 700,000 feet of airport drainage pipe. It is being used—more of it than ever before—in the construction of naval craft and merchant ships. In short, it is performing thousands of tasks for war which will be paralleled in peacetime.

Because of this great and growing importance of wood, Canada's 500 million forested acres take on a new significance, and the work of the logger and the sawyer ranks in importance with that of the miner, the farmer, the munitions maker, or the transport worker, as a major contribution to the United Nations, not only in the war program, but in the era of reconstruction which will follow.

Except in magnitude, such a wartime contribution is not new for the Canadian forester. When Napoleon tried to defeat Britain by blockading her supplies from Europe, the ring of the axe was heard in Canadian woods, Canadian timbers became ships of the Royal Navy, and the blockade attempt was a failure. A century

later another would-be conqueror tried even more strenuously to blockade the British Isles, and once again the woodsmen of this country aided in the victory.

But providing enough timber for the Britain of Napoleon's day, or even for the war of 1914-18, was one thing. Supplying the enormous quantities presently needed by Britain, the United States, and Canada herself, is quite another. Demands have risen so high that production cannot keep pace, and Canada, one of the richest timber countries in the world, is experiencing a deficit.

Actually, the total lumber output since September, 1939, was greater than that of any corresponding period in Canadian history. This total was made possible by three big years, 1940, 1941, and 1942. The present rate of production is at a lower level than the wartime average.

Before the war, 1911 was the year of top production, when 4,918 million feet of lumber were sawn. Figures for the past five years, based for the first three years on compilations of the Dominion Bureau of Statistics and for the last two on estimates of Timber Control, follow:

Year	Millions of board feet
1939	3,977
1940	4,629
1941	4,941
1942	4,800
1943	4,300*

* The decrease from 1942 results partly from the severity of the winter of 1942-43.

What the 1944 figure will be is anybody's guess, but the Timber Controller is hoping for an output not far below that of 1943. Whether his hopes will be realized will depend in large measure on the manpower supply.

Since early in 1942 the demand for labor for all types of war industries has been rising rapidly and enlistments in the armed forces have been at a high rate. As a result,

loggers have been difficult to secure, and this, coupled with the severity of the winter of 1942-43, has caused the drop in lumber output.

For the past two years the average number of men on the payroll in the woods has been about 80,000. In an effort to add to this number, the government granted the industry a labor priority, and endeavored to persuade farmers east of the Rockies to spend the winter in logging operations.

In addition, the government brought back a portion of the Canadian Forestry Corps, which had been employed in lumbering operations in Scotland. The men were directed to Canadian lumber operations.

Meanwhile, the wartime demand for lumber continues to outstrip the supply. Not only is Canadian war consumption as great as ever, but the incessant demands from the United Kingdom and the United States must be met. The record output of 1941, 4,941 million feet, was used as follows: In Canada, 2,640 million (pre-war consumption was about 1,750 million); exported to the United States, 1,232 million; exported to the United Kingdom, 827 million; exported to other United Nations, 242 million.

In 1943, the estimated 4.3 billion feet were used approximately as follows: In Canada, 1,500 million for direct war purposes, plus 900 million for essential Canadian civilian use, including agriculture, housing, and non-war industry; exported to the United Kingdom, 1,000 million; exported to the United States, 800 million; and exported to other United Nations, 100 million. The plans for 1944 call for approximately the same distribution.

When Britain was cut off in 1940 from Baltic sources of supply, she became almost entirely dependent on Canada for lumber imports for direct war uses. In 1944, as in 1943, this country will supply Britain with 70 per cent of her import requirements. The shipments will include about one billion feet of softwood lumber, 18 million feet of Sitka spruce of aircraft quality, 30,000 tons of birch logs for aircraft veneer, 20 million feet of graded

hardwoods, 80 million feet of Douglas fir plywood, approximately 175 million feet of aircraft veneer, 10 million feet of aircraft plywood, and quantities of board made in the pulp and paper mills.

Thus far all agreements with the United Kingdom and the United States for the export of lumber have been kept to the letter. As a result, the close of 1943 saw civilian buyers going begging, and the British Columbia sawmills, which are responsible for 40 per cent of the national output, were having a hard time to keep up with war orders.

So far as the civilian is concerned supplies in 1944 will continue to be limited, although every effort is being made to fill essential orders.

During the past two years the demand for pulpwood has risen to a record peak. A serious shortage developed in 1943, and is likely to become worse unless large numbers of additional woodsmen become available.

In agreement with the United States, this country allowed the export of 1,550,000 cords to American buyers during 1943, or about 80 per cent of what was shipped in 1942. Dealers were forbidden to undertake 1944 commitments totalling more than two-thirds of their sales to that country in 1943.

Historical

At the outbreak of war, the Canadian lumber industry was experiencing a period of reasonable activity. During the first winter the cut of logs was increased but, on the whole, the industry underwent no great dislocation until early in the summer of 1940.

With the Nazi conquest of western Europe, culminating in the collapse of France in June, 1940, the war suddenly became a struggle for survival. Almost overnight, the Canadian lumber industry became virtually the only source from which the United Kingdom could obtain supplies of softwoods essential to the prosecution of the war. At the same time the industry was called on to provide the needs of a suddenly expanded Canadian

war program. Plans for the construction of new munitions factories, and for establishments for the armed services, were revised upwards on a scale that promised to tax the building industry and its suppliers to the utmost. The conflicting needs of exporters, the armed forces, and war industries, threatened the efficiency of the war effort.

To meet this emergency, the Department established a Timber Control on June 24, 1940, and appointed the first of four officials who have held the post of Timber Controller. Before long, regional representatives had been appointed in Vancouver, Edmonton, Winnipeg, and Saint John; regional advisory committees had been set up; and the Ottawa office had been staffed with experienced men from the industry.

Apart from applying the brakes to runaway prices, the heaviest task facing the Control during its first six months was that of purchasing lumber for departmental account and making sure that deliveries were made on time. All such orders were subject to confirmation by the General Purchasing Branch, but the actual placing was done by the Control.

At that time Royal Canadian Air Force projects were built under contract, and the function of the control was to make sure the contractors could quickly obtain the lumber they needed. On the other hand, Army training camps were built by the Royal Canadian Engineers, and lumber for these was purchased by the Department.

By December, 1940, government account purchases had exceeded 110 million board feet and contractors had taken an additional 260 million. In this period, several flying schools, each requiring six hangars and 33 other buildings, were erected in the amazingly short time of 100 days or less. More than 5,000 wooden buildings were built in 1940, and about 4,000 more the following year.

Most striking example of the pressure on the Control in those days was the lumber order for the army camp at Debert, Nova Scotia. First notice of the project was received on a Sunday in August, 1940. Plans and bills

of material for each of 26 types of building were provided by National Defence headquarters, along with the information that two companies of Engineers and about 2,500 civilian workmen would be on the ground on Wednesday, and that it was imperative that lumber should start arriving on that day.

The original designs called for 367 buildings and the Control had to compile within a few hours the gross quantities of lumber of different sizes and grades. It was soon apparent that the specifications included certain sizes larger than available stocks in eastern Canada, and permission had to be obtained to alter the specifications. Although no one mill could fill the order, and the Control had to shop around, the first carloads of lumber were on their way to Debert by Wednesday night, and continued to arrive at the rate of one carload every half hour for many weeks. This one project consumed 25 million feet and there were no demurrage charges.

With the sudden expansion of the war effort, the railways were soon over-burdened, and the Control found it necessary to eliminate cross-hauling as much as possible. Much large timber had to be secured from British Columbia, but otherwise the policy was to buy from the nearest source.

At the same time the Control undertook to scrutinize the specifications for buildings and for all articles made of wood so that the necessary grades might be used wherever possible. In this way the government has saved hundreds of thousands of dollars and much valuable material.

Enormous quantities of lumber go into the making of boxes and crates used for shipping munitions, food, automotive equipment, aircraft, and other war supplies. At the instance of the Control, many types of containers were redesigned by the Forest Products Laboratories of the Department of Mines and Resources, and important savings in lumber and shipping space were achieved.

During the first half of 1941, the demand for lumber was sharply reduced, but by mid-summer a second very active period of war building got underway and continued into 1942.

To offset the shortage of structural steel during this period of greatest construction activity, new techniques in the use of wood were adopted. Huge structures are now being built without steel girders. This was made possible by the use of a recently invented ring connector, which spreads the load on a timber joint over virtually the entire cross-section of the wood. Already more than 700 hangars, drill halls, storage buildings, and other structures requiring a maximum area of unimpeded floor space have been built in Canada with structural grades of Douglas fir held together by the new connectors.

Timber has proved itself in this war. The bombing of Britain has shown that it will stand up better than many building materials. A charred beam that came through the worst destruction of Westminster Abbey has been on display in Canada. Although badly scarred, and burnt to a depth of a quarter of an inch, the beam is still sound and strong.

Because it has been necessary to channel most of the lumber output into direct and indirect war uses, and into exports, the civilian has been subject to severe restrictions. At first these were by informal direction of the Control, but in the first week of 1943 an order provided that no person could buy more than $1,000 worth of lumber or millwork for construction or repairs at any plant, or more than $200 worth for construction or repairs of a building other than a plant, unless a permit has been obtained from Timber Control, or unless the project cost is such that it requires a Construction Control licence and such licence has been obtained. Other orders, passed at various times, prohibit the use of veneer logs or Sitka spruce of aircraft quality for any purpose other than aircraft manufacture. Still other orders, most of which have been issued for the Wartime Prices and Trade Board, have fixed prices on lumber and pulpwood.

Log Exports

During pre-war years logs cut from Crown lands in British Columbia were shipped in volume to the sawmills and pulp mills on the west coast of the United States.

In 1940 restrictions were imposed on these exports so that Canadian production in sawmills and plywood plants could be maintained.

These restrictions were relaxed somewhat in 1941, but were reimposed before the year was over. In the following year the movement of hemlock logs to the United States also was restricted to keep up pulp and paper output in British Columbia.

After negotiation with the Lumber and Lumber Products Branch of the U.S. War Production Board, arrangements were completed for the export in 1943 of 30 million feet of hemlock logs to the United States. Low inventories of fir logs, combined with Canadian war commitments for providing lumber, prevented exports of this species during the first three quarters of 1943, but in the last quarter some small shipments to the United States were allowed.

Lumber Exports

At the beginning of the war, Canada boosted the export of forest products to the United States to improve the foreign exchange position. This policy was abandoned after Pearl Harbor because United States demand increased to a point where it threatened essential United Kingdom and Canadian war supplies.

Nonetheless, exports of lumber to the United States rose substantially. From 450 million feet in 1938, they jumped to a peak of 1,432 million feet in 1942. When the strain on Canadian stocks neared the breaking point in that year, it became necessary to require export permits for all shipments to countries other than the United Kingdom. Permits are now granted for shipments to the United States for war purposes after consultation with U.S. authorities.

Exports to the United Kingdom reached an all-time high of 1,617 million feet in 1940. In the following two years, owing primarily to a shortage of ships, the demand from that source dropped, and when it took a sudden spurt in 1943, difficulties resulted. After negotiation, it was agreed that the United Kingdom would

obtain 40 per cent of all lumber produced on the west coast, and it is estimated that total shipments from the whole of Canada in 1943 aggregated one billion feet.

When exports to Britain took the first up-turn, the abnormal demand for shipping space and the losses in the Battle of the Atlantic combined to prevent shipment from Vancouver via the Panama Canal. Accordingly, railway rates of 82 to 90 cents per hundred pounds were negotiated for the Canadian trans-continental haul. Under this arrangement, still in effect, as much as 60 million feet have been carried from British Columbia to the eastern seaboard in a single month.

Imports

To make more United States dollars available for war purchases, the War Exchange Conservation Act of 1940 prohibited the importation of certain commodities, and placed others under permit. In the latter group were hardwood lumber and flooring, plywoods, veneers, and railway ties. The import permits have been granted by the Department of National Revenue on the recommendation of Timber Control.

Pulpwood

When, toward the end of 1941, United States demand for Canadian pulpwood, pulp, and papers, rose to abnormal heights, and at the same time Canada was facing an increasingly serious manpower shortage, pulpwood operations were brought under Timber Control.

The first step was to place exports of pulpwood to non-empire countries on a permit basis, but it was provided at that time that mills in the United States, which customarily relied on Canadian raw material, would continue to receive supplies based on average purchases during the previous seven years.

The deficit between supply and demand continued to grow bigger, and about a year ago the U.S. War Production Board called for a reduction in newsprint consumption of about ten per cent. The effective reduction is estimated at much less than this, although supplies from Canada have been reduced to 210,000 tons a month as compared with an average of 232,682 tons in 1942.

Production of pulpwood during the operating season of 1942-43 was estimated at one million cords below that of the previous year. Furthermore, the pulp and paper industry claims to have drawn on inventories to the extent of a million cords in each of the past two years.

Pitprops

Britain's coal mines normally depend on the Baltic area for most of their pitwood. When this source was cut off, the British Timber Control set up an organization at Moncton, New Brunswick, known at Pitwood Export Limited.

Even before the war, Britain had obtained experimental quantities, but few Maritime operators were familiar with the rather exacting specifications for this kind of wood. In 1938-39 only 25,000 fathoms were produced. In 1940 the output jumped to 350,000 fathoms (nearly 600,000 cords).

Early in 1941 all contracts were cancelled when lack of shipping space led Britain to boost her own production. About 400,000 cords of the previous year's output were shipped, and the remaining cordage was held by the British Timber Control. Later 100,000 cords of this remainder were released to Canadian pulpwood operators and 30,000 to U.S. operators, leaving a balance of 70,000 which were shipped to the United Kingdom late in 1943.

Hardwoods

Hardwood lumber ordinarily constitutes only six to seven per cent of the total Canadian lumber production. With imports for civilian uses sharply curtailed, and with a cessation of the supply of such woods as teak and Philippine mahogany, domestic hardwoods have come into their own.

The resulting demand has been so great that it was necessary in September, 1941, to place exports of birch and maple on a permit basis, except for shipments to Britain. In 1942 permits were issued for shipment of 92 million feet to the United States. The recent annual exports to the United Kingdom have totalled from 15 to 20 million feet.

Aircraft propeller manufacturers have been helped in obtaining about one million feet of straight-grained birch to meet their annual requirements. About 350,000 feet of this high quality wood was shipped in 1943 to Britain.

Aircraft Spruce

During the first Great War, Sitka spruce, which grows only on the west coast of North America, was found to be the most satisfactory wood for structural components of aircraft. Large quantities were produced at that time, but the demand in this war is even greater.

During the first two years of war virtually all the aero spruce produced in Canada was sent to Britain, but when this country began building its own wooden aircraft arrangements had to be made for release of part of the production intended for export.

In the spring of 1942, the British Ministry of Aircraft Production warned that British aircraft output would be reduced unless more Sitka spruce could be obtained. At the same time Canada was about to go into production of the speedy wooden Mosquito bomber. These two demands constituted a challenge which was accepted by Timber Control. In June, 1942, a Crown company, Aero Timber Products Limited, was established with the sole purpose of boosting the production of Sitka spruce.

The company set up eight of its own camps and supervised private operations. As a result the output rose to 17 million feet in 1942. In the following year the figure stood at 26 million, and in 1944 approximately the same amount will be produced. About two-thirds is now going to the United Kingdom.

All production is allocated. British, Australian, New Zealand, South African, and Canadian requirements are routed through Canadian Timber Control.

Veeners and Plywoods

Selected yellow birch logs are most suitable for producing veneers to the very exacting specifications required for aircraft plywoods. About 80 per cent of Britain's requirements are provided by Canada, the balance by the United States.

Pre-war exports to England were about 10,000 tons a year. These rose to 25,000 in 1940, and 60,000 in 1941.

Early in the war, the British Timber Control sent two representatives to Canada to look after production and purchase of birch veneer logs. Meanwhile, the same British control was placing substantial orders for aircraft veneer and plywood with Canadian manufacturers. Thus, in effect, the British control was bidding against itself for the limited supply of veneer logs.

In May, 1941, the British asked for assistance and the Canadian Timber Control took over all negotiations.

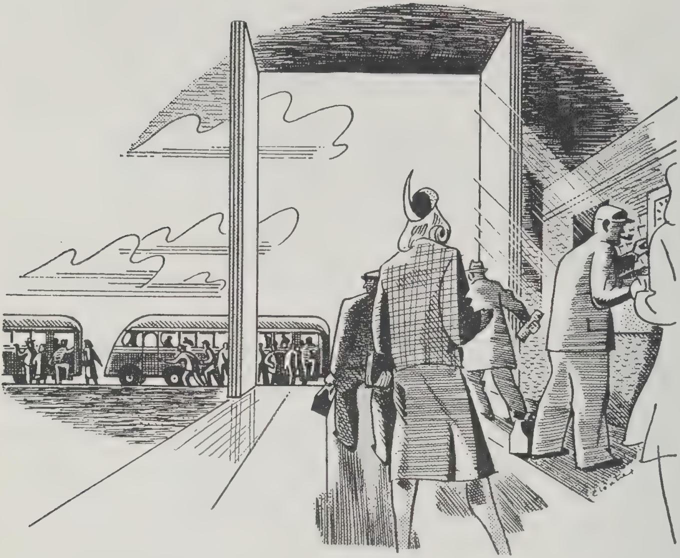
As the overall demand for veneer logs, veneer, and plywood, increased, it became necessary to establish in August, 1942, a Crown company, Veneer Log Supply Limited. With its head office in Montreal, this company supplies all British and Canadian veneer log requirements. Shipments of veneer logs to Britain in 1942-43 dropped to approximately 35,000 tons, but production and export of the finished veneers and plywoods have been expanded substantially.

Eight Canadian companies are now producing aircraft veneer; their combined annual capacity is about 300 million square feet. Four companies make approximately 35 million square feet of aircraft plywood per year.

Early in the spring of 1942, to meet a serious shortage, the Timber Control assumed the responsibility for allocating Douglas fir plywood. Available supplies were denied not only to civilian users, but also to many war projects.

Two Canadian companies operate three fir plywood mills with a productive capacity of about 200 million square feet, but actual production in 1943 was about 160 million feet. Approximately 70 per cent was sent to the United Kingdom, and the remainder used in Canada.

Since the fall of 1942, all Douglas fir log producers on the west coast have been required to make available to the plywood mills all large logs of suitable quality, commonly known as peelers.



TRANSIT SERVICES

BLUEPRINTS for helicopter aerial bus services already have been drafted in Canada. Subway systems have been suggested for large metropolitan areas. And light-metal buses and street cars have been designed for speedy urban and inter-urban travel throughout the country.

But these plans for the post-war world must await the end of hostilities. Meanwhile, women are being recruited to relieve the shortage of bus and street car operators, working hours have been staggered in every large city, transit facilities have been concentrated in areas where they are most needed, bus schedules have been revamped, and non-essential bus mileages reduced.

And despite all these and other steps taken by the government, the curve of bus and street car traffic is

still rising. As compared with 682 million passengers in 1938, these services carried approximately 1.03 billion in 1942, and 1.3 billion in 1943.

Oshawa, risen to new heights of industrial greatness by its contribution of automotive vehicles to all the war fronts, has shown an increase of 450 per cent in traffic as compared with 1939. Windsor, another automotive city, has gained 300 per cent, and Kingston, an industrial-military city, an increase of 251.8 per cent.

Sarnia, where synthetic rubber is now being made, has had to meet a rise of 241.8 per cent, and St. Catharines is not far behind with 239.7. Halifax, one of the busiest of all Atlantic ports, is up 214.7 per cent, and the twin cities of Port Arthur and Fort William, where aircraft and ships are built, show 195.8 per cent. Trailing farther behind are Ottawa, 135.5 per cent; Calgary, 117; Hamilton, 115; Quebec, 103; and Edmonton, 100.

But the worst headaches have been the comparatively small increases of 61.9 per cent in Montreal, 64.5 per cent in Toronto, 83.9 per cent in Winnipeg, and 46.5 per cent in Vancouver. Because of the greater size of these cities, the problem of providing additional equipment and manpower has been more serious than in smaller centres.

In peacetime any increase in public transit traffic can be handled by a corresponding increase in vehicles. But with the raw materials and manpower of North America concentrated on the output of war supplies, only a trickle of new equipment has become available.

However, much of the excess load already is being handled by the private automobile. Under a scheme, known as the Wartime Industrial Transit Plan, approximately 54,000 employee-owners are given special gasoline and tire privileges in return for transporting fellow employees to and from work.

Designed not only as a partial solution of the transit problem, but also as a conservation measure, the plan has proved a success. Under it, fewer cars are being driven

by employees going to work, yet some 217,915 passengers are being carried each working day. The gasoline saving is substantial.

Since the fall of 1941, the Transit Control has placed all buses, street cars, taxis, jitneys, drive-yourself cars, and ferries, under strict regulation. The Control has staggered hours, reduced street car stops, assisted in improving the repair facilities of transit operators, sponsored the rearrangement of seating in existing vehicles, helped hard-pressed operators to obtain new equipment, endeavored to unsnarl parking problems, restricted non-essential bus operation and reallocated the buses thus made available.

In some 28 centres all across Canada the hours of approximately 377,000 office, factory, and store employees, including 39,000 government employees in Ottawa, have been staggered, and further plans in this respect were under way at the close of 1943.

Urban bus mileage has been reduced by approximately 4.7 million miles per year, and inter-urban by about 22 million. These reductions have had the effect of adding to the number of buses available for essential services. Thus by the end of 1943 it was possible to establish 173 new bus services for the employees of war industries, and 82 for the armed services, as well as to add some 500 vehicles to runs already serving war industries and concentrations of armed forces.

Historical

The war was not long under way before it became evident that local transportation facilities in Canada would be strained to the limit. City transit systems, after reaching their peak performance in 1929-30, suffered reverses during the depression years, from which, unlike most other industries, they had not recovered.

The great increase in the use of private automobiles was largely responsible. With traffic during 1933 to 1939 at a level approximately 20 to 25 per cent below that of the 1929-30 peak, transit operators geared their

facilities to meet what they believed would be a permanent condition. Thus the industry was not well prepared to meet war demands.

Before the transit operators had a chance to catch their breath and prepare for the all-time record traffic they would have to carry, war conditions made it almost impossible for them to buy the new equipment they needed.

In 1940 the urban transit industry in this country was called upon to carry nine per cent more passengers than in 1939. The successive increases over the previous year were 16 per cent in 1941, 26 per cent in 1942, and 21 per cent in 1943. At the end of 1943, urban passenger traffic for Canada was 97 per cent above that for 1939.

Faced with an emergency situation, the Department set up a Transit Control on August 12, 1941, and appointed the first of two officials who have held the post of Transit Controller. With broad powers, it was the task of the new Control to prevent a transit bottleneck.

Operators were encouraged to have old equipment reconditioned and put back into service. Wartime transit committees were established in nearly all municipalities where the transit problem was becoming acute, and a beginning was made in the solution of local parking problems, and in staggering hours.

Before the end of 1941 a complete study had been made of all available street car and bus equipment in Canada. The larger transit systems for many years had relied on United States sources for their new equipment, and because of the need for conserving foreign exchange their requirements had been carefully screened.

After Pearl Harbor, it became apparent that the switch-over to war production in the United States would be so greatly accelerated that motor vehicles would be in short supply. The Control at once placed orders with U.S. bus manufacturers for enough vehicles to take care of Canadian needs, and it was arranged that the Control would allocate the vehicles thus obtained.

But U.S. transit operators also were aware of the emergency, and orders poured in to the manufacturers to a total of more than 12,000 buses. Although the U.S. War Production Board stopped the manufacture of buses in July, 1942, and three-quarters of the orders were never filled, Canada was fortunate enough to obtain delivery of 60 per cent of the vehicles sought by the Control.

Beginning in November, 1941, the Motor Vehicle Control progressively reduced the manufacture of chassis for use as buses, and by the spring of 1942 none was being made, except by permit. Thus both the Motor Vehicle Control and the Transit Control were called on to approve applications for new buses to be made in this country.

Upon the resignation of the Controller on April 14, 1942, the Deputy was given the post and an Associate Controller was appointed. At the same time the Control office was moved from Montreal to Toronto, and shortly thereafter regional directors were appointed in Vancouver, Regina, Toronto, Ottawa, and Halifax. Later the Regina office was moved to Winnipeg, and subregional offices were opened at Edmonton, Windsor, Kitchener, St. Catharines, Hamilton, Ottawa, Quebec, and Saint John. The staff of the Control grew to 100.

Street Cars

One of the many strange developments of this war has been the about-turn in the trend toward abolishing street cars. When buses became scarce, Transit Control successfully urged the reinstatement of service on several electric lines. Old street cars have been resurrected, refitted, cleaned, painted and put back in operation. Old trackage not serving a useful purpose has been dug up and used elsewhere. New tracks have been laid, extensions made, and new Y's and loops installed to permit shortening of runs in the rush hours.

Still the most economical mode of transportation, the street car is not likely to end its usefulness after the war. Instead, new and lighter street cars will be built, and the service will be speeded up. Plans for subways have

already been devised, and their installation is being seriously considered as a post-war measure in large metropolitan areas.

By the end of 1943, at the instance of the Control, tramway systems in all large centres had eliminated scores of intermediate stops. With the co-operation of local wartime transit committees, parking on busy streets in Montreal, Ottawa, Toronto, Winnipeg, and other large centres, had been severely curtailed to enable public transit vehicles to complete their runs in shorter time and thus carry more passengers per hour.

Buses

The control over buses was necessarily more severe than that over street cars. Early in 1942, charters for sightseeing trips, week-end excursions, and other luxury bus runs, were ruled out.

Wherever possible, electric railway lines, which had been abandoned in favor of bus operation, were rehabilitated and put back into service, and the bus operation stopped. Where steam railway services were reasonably convenient, duplicating inter-urban and suburban bus services were withdrawn. Bus lines paralleling street railway lines were prohibited altogether, or restricted to peak hours.

In addition, extra-fare urban buses were curtailed, as well as certain feeder lines, certain special night services in the larger cities, and some other non-essential services.

But all these steps did not add up to a sufficient reduction in mileage. Accordingly, in November, 1942, the Control restricted the sale of a bus ticket for any trip exceeding 50 miles in one direction. Exemptions were granted where it was shown that service beyond the 50-mile limit was really needed and where train services were inadequate. As a result, however, a wholesale re-scheduling of bus routes was made possible, and the buses thus freed were allocated to crowded industrial and military areas.

Exemptions in the application of the order included those routes which provided the only reasonable means

of public transportation. Lines on which traffic was negligible were discontinued entirely, but where the traffic warranted a service, the 50-mile restriction was modified to permit the operator to obtain profitable loads, provided he did not increase the number of buses on any scheduled trip. Such modifications were accomplished either by increasing the distance limitation, or by allowing a fixed number of passengers per bus to be carried between terminals more than 50 miles apart.

Taxis

When gasoline rationing went into effect on April 1, 1942, taxis were classed as commercial vehicles and were then allowed gasoline to the extent of their proved normal requirements. Because of progressively reduced rations to the private motorist, and because of the general upswing in business activity, the taxi operators were doing a record business, and in order to conserve gasoline, rubber, and automotive equipment, it became necessary to restrict their operations.

The first control step was to freeze the number of taxis in operation to the level of 1941. But with gasoline supplies dwindling rapidly, it became necessary to reduce this number by 20 per cent, and by November 15, 1942, the taxi gasoline ration also had been reduced to an average of 150 gallons per cab per month, varied by quarters through the year from a minimum of 140 gallons in summer to 160 gallons in winter.

Soon after the first freezing order, the Control required the registration of all taxis, and thereafter every approved cab carried a marker and bore on the windshield the name of the municipality in which it was stationed. The same order limited taxi operations to a radius of 15 miles of the home town, except in case of emergency, in which instance a report had to be submitted to the Control within 24 hours. The use of a taxi for the delivery of goods or for sightseeing trips, was forbidden.

At the same time the Control urged taxi operators to pool their facilities in each city by providing a central despatch bureau. Later the type of taxi trip deemed

essential by the Control was clearly defined, and efforts were made to arrange for multiple riding to provide maximum service with minimum mileage.

The number of taxis in service in Canada has dropped from approximately 13,000 in August, 1942, to about 10,000 at the end of 1943.

Drive-Yourself Cars

Drive-yourself cars were first placed under regulation in June, 1942, when an order limited their release for hire to the hours between 6 a.m. and 11 p.m., except in an emergency. This first order also restricted the renting of such cars to certain classes of customers.

In December, 1942, the order was tightened, and it was provided that a drive-yourself car could not be rented by anyone except for a business purpose or in an emergency, but not for the delivery of goods. All trips must be reported monthly.

Drive-yourself cars have been placed on the same gasoline ration as taxis.

Ferries

As a result of arrangements made by the Control, a new ferry was purchased to serve North Vancouver war industries, and an additional ferry was put into service between Halifax and Dartmouth, Nova Scotia.

Wartime Industrial Transit Plan

In pre-war years fully half the essential urban transportation in Canada was provided by the private motor car. Pooling did not originate with the war, but the shortage of gasoline and rubber made it a popular and patriotic necessity.

But ordinary car pooling does not necessarily accomplish much. To achieve the greatest results in conservation of gasoline, rubber, and equipment, it has to be carefully organized, and the objections, such as legal liability, must be overcome.

The Wartime Industrial Transit Plan, initiated by Transit Control and worked out in conjunction with

Oil Control and Rubber Control, has been the answer. Under it, fewer passenger cars are driven to war plants and each car so driven is utilized as fully as possible on every trip. By the end of 1943, the plan had been established in more than 2,000 industries with a total payroll of 953,000 employees, of whom 217,000 were dependent on W.I.T. transportation. An average of about four persons were being carried in each car operating under the plan.

The plan permits certain approved plants to choose carefully a sufficient number of employee owner-drivers, whose responsibility it is to provide the transportation needs of fellow workers not adequately served by public transit systems. These approved owner-drivers are entitled to special gasoline, tire and repair privileges. Each month they are granted extra gasoline coupons, and when the necessity arises they are permitted to purchase tires or tubes.

Any company which wishes to use the plan must first make a survey of the transportation problems of its employees. If the Transit Control approves the establishment, a Plant Transit Officer is appointed. It is this officer's duty to administer the plan in his plant.

Although the plan was ready late in the fall of 1942, only a small number of firms availed themselves of its advantages until April 1, 1943, when drastic new gasoline regulations went into effect. The plan is available only to war industries and to such groups as are sanctioned by the Oil Control and the Transit Control.

TRANSPORT SERVICES

THANKS to the early pioneers whose daring and foresight pushed the end of steel across a continental wilderness, and to the wisdom of those who kept the industry in good shape throughout the years of depression, the railroads of Canada have taken in their stride one of the biggest transportation jobs in all history.

Together with ocean, lake, and river ships, and with freight and passenger planes, they have made possible a war program, enormous by all accepted standards, phenomenal by any standards applicable to this country.

Over the longest trackage in the world, the railways have transported the materials with which Canada's industrial capacity has been doubled. They have carried the ores, metals, oil, coal, and other raw materials to feed

this giant industrial machine. And they have also carried the millions of tons of end-products going to every fighting front in the world, foodstuffs for the Allied nations, and necessities for the home front.

In addition, they have linked 300 or more establishments of the armed forces in every corner of the Dominion, carried hundreds of thousands of men and women in uniform to their ports of embarkation, and speeded many millions of pounds of vital express and mail.

Yet never once, since the outbreak of war, has any large-scale item in the Canadian war program been hampered because the railways failed to deliver the goods or the men on time. Even during the worst of the unprecedented storms of the 1942-43 winter, save for some few delays, the trains kept running and the war effort remained in high gear.

With the flow of traffic in the last pre-war year as a yardstick, it would have taken more than two years to move the volume of freight carried on Canadian railroads in 1943. More specifically, the 1943 tonnage was about 176 million as against 81.6 million in 1938. The increase was approximately 115 per cent.

But the volume of freight is one thing; how far it is transported is quite another. The ton-mile total for 1938 was 26.78 billion. That of 1943 is estimated at 63 billion, a jump of 135 per cent.

Every day more than 9,330 freight cars start a new journey. Every day from 800 to 1,000 tons of export meat, or enough to feed greater Ottawa for a month, are loaded at the packing plants. Every day in the last few weeks of 1943, a total of 1,400 box cars of feed grain were loaded in the west. In terms of bread, this would supply the whole of Britain for four days.

Even more startling has been the rise in passenger traffic. The number of men, women, and children carried on Canadian railways in 1938 was less than 21 million. Including the armed forces, the number of revenue passengers carried last year was approximately 54 million,

an increase of 157 per cent. In the same period passenger-miles rose by 263 per cent, from 1.783 billion to 6.474 billion.

If the railways had been faced with traffic on this scale in peacetime, they would have built more locomotives, more freight cars, more passenger cars. They would have increased their payroll. But up against the wartime shortages of materials and manpower, such solutions were impossible on a scale commensurate with the need. Since the outbreak of hostilities, the net addition of locomotives has been a mere 1.75 per cent, of new Canadian freight cars only 2.7 per cent, and of all freight cars, including United States and private line cars operating on Canadian lines, only about 17 per cent. The net manpower increase has been only 32 per cent.

Railway enlistments so far in this war have totalled more than 30,000, which is roughly one-quarter of the pre-war operating payroll. By taking on new personnel and providing them with an intensive schooling, the railroads have done a little better than make up this loss. At the end of 1943 the total operating payroll stood at about 157,000, as against 119,228 in 1938. Some 1,400 of the new employees are women.

Confronted with the manifold difficulties of wartime operation, the railways have been able to do their job efficiently because of four factors: Firstly, the morale of the operating personnel was high in peacetime and has remained high; secondly, equipment, roadbeds, and rolling stock were not allowed to deteriorate during the depression years; thirdly, by government regulation special fares and other travel inducements were removed, cross-hauling was kept to a minimum, and maximum freight loading was made mandatory; fourthly, in recent years the two large railroads have developed and put into use newer, more powerful, and more efficient locomotives, and thus have been able to increase the number of cars in each train.

An astonishing degree of car utilization has been achieved. The average load for each freight car loaded at stations in Canada has risen since the beginning of

the war from 27.1 tons to 30.6, and the average number of passengers per train from 48.3 to 115.9.

Today the lowly freight is King of the Road. It has its rights and it has its schedules. Even the crack passenger express may be pulled into a siding to let it pass. Back in 1921 the motorist at a grade crossing hardly had time to light a cigarette before the average freight of 37 cars had ambled by. Now he can safely shut off the ignition, light up, lean back, and wait for seventy, eighty, ninety, or even as many as 130 cars to roll past, often at mail train speed.

One type of passenger train is rarely, if ever, held up by a freight. It is the commuters' special which carries war workers. Each day the Canadian National and Canadian Pacific transport about 40,000 men and women to and from their work in explosives, aircraft, and other war plants.

Of the many occasions when passenger trains have had to yield first place to freights, the movement of a steel tower from Lachine, Quebec, to the government-owned synthetic rubber plant near Sarnia, Ontario, is an outstanding example.

A special job from its first blueprinting to its final installation, the tower measured 165 feet in height and 12½ feet in diameter, and weighed 150 tons. It had to be specially built, specially loaded on three flat cars, and hauled by a special train. It comprised the largest unit shipment ever made in Canada.

Never except on state occasions, such as the visit of the King and Queen in 1939 or the Quebec conference of 1943, have so many precautions been taken by a Canadian railway. Everywhere the shipment was given the right of way. Even the crack Chicago-Montreal expresses had to allow the pokey little freight to pass. Moving only by daylight and at no more than 15 miles an hour, the train took five days to do the 500-mile journey. It comprised an engine, a rusted old rock car as a "floater" between the load and the engine, the three flat cars bearing the tower, and two cabooses for the crew.

Up in the cab, the engineer probably found difficulty in keeping his locomotive down to the required speed. A veteran of 40 years of railroading, he was used to pushing the big 6100-type engines with a string of 100 or more box cars. On this run the slow speed was an extra precaution for safety. Track men rode with the train to inspect the rails and bridges before the load went across.

Flat cars with a depressed centre were used on this job, and in other noteworthy movements of odd-sized freight. Specially built and largest in Canada, these cars have carried corvette boilers, a large steel-welded boat, and a 134-ton transformer.

Air Transport

The future of air transportation in Canada is assured. The war has meant expanded airfields, radio, and meteorological services. It has brought about the establishment of new routes—such as the Alaska run which helped to make possible the Alaska highway—and the extension of old routes.

Even before the war more air-borne freight was carried in Canada than in any other country. Apart altogether from the carriage of goods and men in service planes, that traffic has greatly increased. Trans-Canada Air Lines, a subsidiary of the government-owned Canadian National Railways, has increased its regular routes by 900 miles and has added a service to Britain since the outbreak of war. In 1943, it carried approximately 141,000 revenue passengers, as compared with 104,446 in 1942. In addition, in 1943 it carried about 3.9 million pounds of mail and approximately 840,000 pounds of express, as compared with the 1942 figures of 2,308,812 and 362,837.

Canadian Pacific Air Lines, a subsidiary of the Canadian Pacific Railway, carried 9.1 million pounds of air cargo in 1943, as against 9.6 million in 1942. In the same years respectively, it transported 70,000 as against 60,000 passengers, and 2.2 million, as against 1.75 million pounds of mail.

About 90 per cent of the traffic on both lines is directly connected with the war effort.

Steamship Transport

In steamship traffic, too, Canada has broken all previous records. In 1942, for instance, the Great Lakes fleet, comprising 700 vessels belonging to Canada and the United States, carried 92.1 million tons of ore to the steel mills of both countries. Never before had any such tonnage of one product been carried on these lakes. Last year, in spite of a late start, about 85 million tons were carried.

The Great Lakes fleet transports not only ore, but also oil, coal, grain, metals, steel, and many other essential commodities. Operating under war conditions, it is carrying what is most urgently needed without regard to pre-war restrictions on international freight movements. Many of its ships have been diverted to ocean service, and some have been lost by enemy action.

But the full story of air and ship transport must await the end of the war. Amazing accomplishments of daring and of enterprise are still secret.

Transport Control

At the outbreak of war, Canada had nearly 43,000 miles of railway. Of this 51 per cent was operated by the Canadian National, 40 per cent by the Canadian Pacific, and nine per cent by other roads. The war was not an hour old before the importance of these lines was emphasized by the appearance of armed guards at bridges and other vulnerable points.

It was early recognized that congestion must be avoided, and that service personnel and essential supplies must be given transportation priority. Accordingly, the government set up a Transport Control under the Department of Transport, and appointed a Controller who later also became a member of the Wartime Industries Control Board of the Department of Munitions and Supply.

With headquarters in Montreal, and an office in the Munitions and Supply buildings in Ottawa, the new Control quickly instituted a permit system covering the movement of raw materials and war supplies in which the Canadian and foreign governments were interested.

All contractors and shippers for government account were ordered to ask the Control for permission to move freight to the seaboard for export. Ocean space was secured from the British Ministry of War Transport, the War Shipping Administration of the United States, and other government agencies. The permits for shipment to the seaboard were timed so that goods would not arrive before shipping space was available.

Whenever required, the Control arranged for the orderly movement of men and women of the armed forces to various training camps and other centres in Canada, and to Newfoundland, Labrador, the West Indies, the Aleutians, and in great numbers to Britain. Special train services were organized to handle the traffic to and from the hundreds of camps scattered throughout Canada.

In 1941, the Control set up a carloading division to give advice on the proper loading of raw materials and war supplies. This division also co-operated with other control bodies to cut down packaging sizes and thus save rail and ocean space.

Early in 1942 the railroads were beginning to experience some difficulty in handling the enormous volume of traffic that was developing. To conserve their manpower, equipment, and fuel, and to enable the fullest use of their facilities for war purposes, the Control during that year prohibited ski trains and other specials not authorized for the movement of the armed forces or war materials. It cancelled convention fares and certain other special fares, and through the Department of Munitions and Supply it issued an appeal to all Canadians to forego travel when the service personnel were on Christmas leave.

In addition, the Control issued orders compelling the carrying of greater loads of fruits, vegetables, and other produce, in refrigerator cars, and increased the penalties charged the users for holding such cars longer than is necessary to load or unload.

But the most far-reaching orders came in 1943. In January of that year, the Control issued a maximum carloading order, which provides, as far as possible, that

every freight car must be loaded to capacity on every trip. The carloadings of the Canadian railways have at times reached 75,000 per week, a sharp increase over pre-war peaks. Several thousand cars per week were added to the available carrying capacity by reason of the savings in car space achieved through this order.

Faced with a possible interruption of essential traffic during the extreme winter and spring of 1943, the Control extended its appeal to civilians to keep off the trains. At the same time, it curtailed or removed chair cars, dining cars, and sleeping cars on certain routes, and limited extra sections.

However, civilian travel continued to climb, and before the end of 1943 the Control found it necessary to suspend week-end fares, summer fares, and 21-day-limit fares, and to curtail summer resort services.

The grip of the winter of 1942-43 was late in relaxing, fields were left too wet to plant, and in eastern Canada a partial failure of the feed crops resulted. During the summer the situation was declared an emergency, and the Transport Controller was asked to set up a grain committee with wide powers.

To carry sufficient grain to the lakehead before the close of navigation, a substantial number of box cars were taken west and a shortage of this rolling stock developed in the east. To counteract this shortage, the Control urged the postponement of all shipments which could be delayed without loss to the war effort. Christmas trees were among the items affected.

In addition to the movement to the lakehead, which accounted for about 1,100 carloadings a day, the Control arranged for an all-rail movement of a maximum of 300 cars a day from the prairies to the east. If the winter of 1943-44 proves reasonably moderate in the west and in northern Ontario, the supplies thus moved should take care of the demand.

Arrangements also were made to assist the United States in securing Canadian feed grains. Before the winter is over about 100 million bushels will have crossed the border.

Early in its history the Control established a division to charter freight and passenger steamers to handle contractors' supplies, and military and Air Force equipment and personnel. Regular services have been operated to Newfoundland, Labrador, and the West Indies. On these ships have gone all the materials necessary to build Canadian service establishments, airports, docks, and other defence works. In addition, the ships have been used on behalf of the government of Newfoundland to transport essential supplies to that British colony.

Some of the ships chartered carried the supplies and workmen needed to build the monster airport at Goose Bay in Labrador. During the summer of 1943 a total of 50,000 tons of package freight, contractors' supplies, and service equipment, were taken to that destination without loss. At the same time a small passenger ship, with refrigerator equipment, was operated on the same route. A shuttle service also was established to link Goose Bay with its outpost at Rigolet.

To make possible its shipping service to Goose Bay, the Control installed several oil tanks and pipe lines, and built a good-sized warehouse and a dock capable of handling three small freighters.

As the Newfoundland projects have been brought to completion, ships have been removed from the service. But the Control is still responsible for carrying 75,000 tons of coal per year to supply the airfields at Gander and Botwood.

CROWN PROPERTIES AND CROWN COMPANIES

IN THE four years of war Canada has passed through an industrial expansion unparalleled in her history. This expansion has been achieved by the creation of new plants and new equipment representing an investment of over one billion dollars.

The newly created manufacturing facilities have a value equal to the total depreciated valuation of the pre-war investment in plant and equipment of all manufacturing industries in Ontario, as given in the Canada Year Book. This is to say that the new facilities are worth approximately half the depreciated pre-war value of all manufacturing industries in Canada. While this comparison has obvious shortcomings and exaggerates the actuality, nevertheless it does give scale to the accomplishment.

New facilities have been provided for the manufacture of war material of every type, for the production of equipment ranging from guns to ships, from instruments to parachutes, from shells to planes, and for increasing the production of raw materials and other supplies.

The Canadian government pursued one basic policy in creating or encouraging the creation of these new facilities. This was to assure that plants were built as rapidly as possible—for speed was of imperative importance—and as sparingly as possible of public funds.

Excluding plants financed privately without government assistance of any kind, these four methods of financing were employed to expand productive capacity:

1. The government provided funds for, and retained the ownership of complete plants, having them operated by private interests on a management-fee basis, by specially created Crown companies, or by existing government organizations such as the Arsenals.

2. The government provided funds for additions to existing, privately owned plants. These additions are mostly machinery. They remain the property of the Crown and may be removed at any time at the discretion of the Crown.

3. Where the new facilities were to form an integral part of existing plant and would thus have little independent value, the effort was made to have private interests finance new plant and equipment by a special arrangement, justifiable only on equipment of value solely for war production, under which capital expenditures made by the contractor out of his own funds could be charged to manufacturing costs as special depreciation. After rigid examination of the project, the contractor was authorized to proceed, and he obtained a certificate from the Department certifying that the new plant was essential for war needs. When the project was completed and all the necessary funds spent, application for what was called "Special Depreciation" was made by the contractor to the War Contracts Depreciation Board—a body of judicial status expressly created for the purpose. After assessing the post-war value of the plant, the board determined the depreciation to which the contractor was entitled, and determined, too, the term of years over which the depreciation would be spread.

4. The Department of Finance, under the terms of the War Exchange Conservation Act, also permitted some companies to obtain special depreciation or depletion allowances for plant expansion. These extensions were confined chiefly to a few mining and lumbering operations and it was inherent that the assets created should have a wartime value only. This plan was adopted only where the increased facilities would bring in U.S. funds, at one time sorely needed.

Thus, in essence, plant construction was carried out on two bases: one in which the title remains vested in the Crown, and one in which the contractor financed and retained the ownership of the property, the choice being governed by the varying circumstances prevailing. Generally speaking, it has been the consistent policy of the Department to retain ownership of all properties,

plants, and equipment created by public funds, save in those instances where the property formed an integral part of, and was not severable from existing privately owned plants or equipment.

It was found uneconomic to retain ownership in extensions or appurtenances built into existing undertakings. Such facilities could have little or no post-war value except to the owner of the plant where they were located. They could seldom be removed except at considerable expense, and their removal would usually destroy all or nearly all of their value. Thus, the effort was usually made to have the manufacturer assume the financial obligation for increases in productive facilities of this nature, under the plan for special depreciation already described.

Until the fall of France in 1940, and for a good many months thereafter, Great Britain placed orders in Canada for explosives, shells, ordnance, aluminum, and other supplies which involved the creation of new manufacturing facilities, and the United Kingdom financed these facilities and retained title to them. Later, when Great Britain ran short of Canadian funds, the administration of all these contracts, together with the ownership of government properties, was taken over by Canada. The formal transfers were not all completed until March, 1943.

It was only after the fall of France that the plant expansion program in Canada gained great momentum. Prior to that time the United Kingdom did not try to utilize the full industrial potentialities of the Dominion. Indeed, her own domestic industries had not been harnessed to the full. Nor had Canadians themselves yet realized the meaning of total war. Thus it was only with the deterioration of the situation in France that the plant expansion program got into full swing.

The total expenditures for new plant construction, including housing, amount to approximately $1,100 million, of which less than 30 per cent was undertaken and financed by private interests which have obtained

special depreciation concessions. A sum approximating $800 million has been spent to provide plant, equipment, and housing of which the Crown remains the sole owner.

The growth of the productive facilities, owned by the people of Canada and operating under the Department of Munitions and Supply, is presented statistically by the following figures showing the commitments—not the actual expenditures—of the Canadian and British governments for these purposes since March 31, 1940:

Quarter	Millions of dollars
March 31, 1940	30*
June 30, 1940	110
September 30, 1940	230
December 31, 1940	310
March 31, 1941	380
June 30, 1941	510
September 30, 1941	550
December 31, 1941	570
June 30, 1942	715
September 30, 1942	780
December 31, 1942	800
June 30, 1943	850
December 31, 1943	856†

*Not included in this figure are certain commitments made by the United Kingdom government through the United Kingdom Payments Office (originally the United Kingdom Technical Mission). Subsequently, the administration of these expenditures was taken over by the Department of Munitions and Supply and they are incorporated in the later figures.

†The actual expenditures are somewhat less.

Included in the earlier figures in this tabulation also are some millions of dollars used as liquid capital or to build up stockpiles.

While the foregoing are the statistics, they hardly present an accurate picture of the actuality, particularly in the year from June, 1940, to June, 1941, when, with Britain standing almost alone, Canada was building with feverish haste the necessary new facilities for war production.

In the urgencies of such times, the statisticians did not keep pace with the actuality. Great plants were begun the moment a broad authorization was obtained from the government. Oft-times they were nearly completed before the figures could find their way to the statisticians.

The percentage of fixed capital commitments by the government as at December 31, 1943, by classes of products is as follows:

Nature of Production	Percentage
Aircraft	10.3
Ammunition	15.6
Chemicals and Explosives	18.4
Guns, Mountings and Carriages	17.8
Machine Tools and Gauges	.7
Mechanical Transport and Armored Vehicles	4.2
Raw Materials, Non-end Products, Miscellaneous	17.5
Signals and Instruments	1.7
Shipbuilding and Ship Repairs	4.7
	90.9
Housing	9.1
Total	100.0

Of a total commitment of $865 million for new production facilities, some $600 million has been allocated to provide plant or equipment owned by the Crown and operated by private interests. The remainder has gone into plants operated by Crown companies, plants such as arsenals operated directly by the Crown, and other miscellaneous projects including housing.

Generally speaking, the largest expenditures for individual plants have been made in the chemicals and explosives and shell-filling industries. For these, several large plants have been constructed at a cost of 10 to 20 million dollars.

However, many millions have gone into individual plants providing raw and semi-fabricated materials. The Crown owns furnaces and finishing equipment costing millions, and has spent many millions to construct or expand a wide variety of facilities producing critical materials, particularly base metals. Substantial sums have been spent to provide other raw materials such as timber and plywoods for aircraft.

Canada owns several aircraft plants. While the investment in this industry is not as substantial as in others, nevertheless some of these plants have cost from 2 to 6 million dollars.

A large proportion of all these expenditures has gone to provide costly tools and other equipment necessitated by the exacting standards of quality needed in war production. These standards far transcend those employed in the manufacture of goods for civilian use.

It is to be borne in mind that a large part of the expenditures was for plant and equipment which would have no utility in the peacetime economy of Canada. Much of the capacity created is far in excess of any civilian needs presently visualized. Brass output, for instance, has been expanded more than thirty times Canada's normal requirements. Many of the machine tools will do one task only—boring gun barrels, for example—and cannot be converted to civilian use, except at a cost higher than that of completely new machines. The problems of utilizing or scrapping such plants and equipment will not be simple after the war. It is true, however, that Canada has grown much greater in the variety of items she can manufacture for herself and for world trade, and also in her manufacturing techniques. She will bulk larger in the world as a manufacturing nation.

A large expenditure has been made on properties operated directly by the Crown, as opposed to those operated by Crown companies or by private interests on a fee basis. The largest of such undertakings include the Arsenals. But the administration of properties operated by the Crown has usually been placed in the hands of one of the 28 companies wholly owned by the government. Of these, nine operate plants. The others fulfill administrative or purchasing functions.

These Crown companies were organized not only to solve production problems, but also to surmount certain supply, purchasing, and administrative difficulties. Through their creation, the Dominion was able to benefit from the experience of their carefully chosen directors, all of whom serve without remuneration. In addition, the companies provide a mechanism to which business men are accustomed, and permit a degree of decentralization essential for operations in as large a sphere as the Department of Munitions and Supply.

The Crown companies operate directly under the Department. Their accounts are audited by the Auditor General of Canada. Their financial arrangements are submitted to, and subject to, approval of the Privy Council.

The following tabulation lists these Crown companies according to their dates of incorporation:

Name of Company	Date of Incorporation
Fairmont Company Limited Purchases and sells stocks of natural, synthetic and salvage rubber.	May 16, 1940
‡Plateau Company Limited Purchases and sells silk, nylon, and kapok.	May 16, 1940
Citadel Merchandising Co., Limited Purchases, distributes, and allocates machine tools.	May 17, 1940
Federal Aircraft Limited Administers Anson plant program.	June 24, 1940
Research Enterprises Limited Produces optical glass, fire control devices, and radiolocators.	July 20, 1940
Allied War Supplies Corporation Administers the chemicals and explosives program.	July 23, 1940
Small Arms Limited Produces service and automatic rifles.	August 7, 1940
‡Melbourne Merchandising Limited Purchases and sells wool.	September 26, 1940
Atlas Plant Extension Limited Supervises the financing of Atlas Steels Limited.	October 7, 1940
National Railways Munitions Limited Produces guns and gun carriages.	February 14, 1941
Wartime Housing Limited Constructs and operates housing in industrial areas.	February 28, 1941
¶Wartime Merchant Shipping Limited Administers cargo ship construction program.	April 4, 1941
War Supplies Limited Negotiates munitions orders placed by the United States in Canada.	May 13, 1941
Trafalgar Shipbuilding Co., Limited Administers procurement and priorities on materials for ship program.	August 7, 1941
*Toronto Shipbuilding Company Limited Administers a naval shipbuilding yard.	October 21, 1941
Cutting Tools and Gauges Limited Salvages and reconditions cutting tools.	November 14, 1941
Machinery Service Limited Overhauls and reconditions machine tools.	December 22, 1941
Wartime Metals Corporation Is responsible for emergency projects covering the discovery, mining, and refining of non-ferrous war metals.	March 17, 1942
Polymer Corporation Limited Built and operates a synthetic rubber plant.	March 27, 1942
Park Steamship Company Limited Controls the operation of newly built Canadian cargo vessels.	April 8, 1942
Aero Timber Products Limited Produces and purchases Sitka spruce for aircraft.	June 19, 1942

Veneer Log Supply Limited ....August 13, 1942
Supervises cutting, purchases, and ships, hardwood logs for aircraft veneers.

Victory Aircraft Limited ....November 5, 1942
Builds Lancaster bombers.

North West Purchasing Limited ....February 19, 1943
Purchases Canadian requirements for U.S. Army in the northwest.

Defence Communications Limited ....April 3, 1943
Co-ordinates and operates communications systems on behalf of the armed forces.

Wartime Oils Limited ....May 4, 1943
Expedites development of Canadian oil sites.

Quebec Shipyards Limited ....June 16, 1943
Co-ordinates the shipbuilding activities in a group of Quebec yards.

War Assets Corporation Limited ....December 3, 1943
Will dispose of, or utilize surplus war assets.

‡Plateau Company went out of existence at the turn of the year, 1943-44, and its functions were taken over by Melbourne Merchandising Limited.

¶Renamed Wartime Shipbuilding Limited at turn of 1943-44 and given responsibility for combat vessels as well as merchantmen.

*Toronto Shipbuilding Company was to be wound up early in 1944 and its charter surrendered.

The functions of War Assets Corporation Limited were defined by the Prime Minister as follows:

"The company will be authorized to hold, manage, operate or sell property entrusted to it, to convert surplus materials to basic products, to hold stocks pending ultimate disposal, and generally to handle the assets assigned to it in the public interest.

"In other words, the Cabinet will, from time to time, decide what assets are to be assigned to the Crown company, the Cabinet's decisions being made in the light of reports received from the Crown Assets Allocation Committee. The assets to be disposed of by sale will be consigned to War Assets Corporation Limited. The new Crown company will operate subject to basic policies to be laid down by the government."

The operations of the other Crown companies are outlined in the appropriate chapters of this volume.

ADMINISTRATION AND OPERATION

THE Department of Munitions and Supply, like all Gaul, is divided into three parts. These parts are the production branches, the controllers, and the administrative and other branches designed to co-ordinate or make more effective the operations of the Department as a whole.

Each sphere of production is administered either by a branch of the Department or by one of the Crown companies engaged in the actual production of munitions.

The officials directing the work of the gun, aircraft, ammunition, arsenals, and other production branches, together with the presidents of some of the Crown companies, are all members of the Production Board of which the chairman is the Co-ordinator of Production of the Department. Through this board the munitions program is kept in balance with the needs of the Allies and the supply of raw materials.

In a similar fashion are the operations of the controls co-ordinated. The 16 Controllers, together with the Priorities Officer and some others, are members of the Wartime Industries Control Board, of which the chairman is the Co-ordinator of Controls of the Department.

Co-ordination is attained between these two departmental boards through the chairmen, each of which is a member of both boards. The Wartime Industries Control Board, in turn, has an interlocking membership with the Wartime Prices and Trade Board.

The results of the operations of these boards and their individual members have been fully covered in preceding chapters. Directing these two major fields of operation lies the administration of the Department under the Minister together with a variety of branches without which the Munitions and Supply machine could not have operated.

There are, for example, those important branches operating in conjunction with the Financial Advisor whose responsibilities include assuring that munitions contracts conform to departmental policy and the maintenance of that vigilance over financial and contractual undertakings essential in the disbursement of public funds.

Also operating in conjunction with the Financial Advisor are a group of branches, such as the Munitions Contracts Branch, whose functions are largely along contractual lines, together with several of the Crown companies engaged in trading rather than productive operations.

There are also several branches operating directly under the Deputy Minister. The chief of these are the comptroller's, secretary's, and legal branches. The comptroller is responsible for all accounting matters and for the control of all expenditures including those of the twenty-seven Crown companies operating under the Department.

The comptroller is also charged with the maintenance of all records of purchases of a capital nature, including all real estate, buildings, machinery, machine tools, equipment, jigs, tools, dies, and gauges, the title to which is vested in the Crown.

Under the Secretary's Branch comes much of the day-by-day work of the Department. Some measure of the routine involved in its operations may be obtained from the extent of the flow of departmental correspondence which, in the second quarter of 1943, reached a peak with an outgoing mail in one day numbering some 16,000 individual items. The number of teletype messages received and dispatched also touched its peak in the middle of 1943 when in one month they numbered 75,000 messages. During the past two years the number of telegrams received each month has frequently far surpassed the 5,000 figure. In addition to the communications division and other operations directed by this branch, the secretary is also charged with arranging the detail in connection with the acquisition of all land.

The Legal Branch has drafted tens of thousands of intricate contracts, orders-in-council, and other instruments which have contributed to the smooth running of the war program. In addition, it has been responsible for the investigation of allegations of dishonesties in connection with contractors. However flimsy these may have appeared on the surface, they have all been investigated. If the evidence warranted action, prosecutions were immediately instituted.

An important function of the Department is to provide an adequate system of priorities for materials required in the war program. This is handled by the Priorities Branch which operates with the Co-ordinator of Controls of the Department. Like a variety of other branches, its operations cut across those of the entire department, and, indeed, affect many other control agencies of the government.

This branch has quietly arranged all the priorities of Canada for the war effort. It has arranged that Canadian producers obtain the necessary priorities in the United States and in the United Kingdom. It has, in turn, arranged for priorities in Canada on behalf of Britain and the United States. In Canada, the priority system is operated on an informal basis by direct arrangement with thousands of contractors. In connection with purchases of items in the United Kingdom and the United States, the Priorities Branch has utilized the routine set up in those countries, and has succeeded in obtaining most favorable priority consideration for Canada. Adequately to outline the operations of the priority system in Canada would require at least another volume.

The Department maintains a variety of service branches to meet general administrative and other needs. There are, for instance, the Montreal and Toronto offices operating as units, and these offices at the same time house officials of individual branches of the Department. There is the Economic and Statistics Branch on which the Department relies for the facts without which decisions cannot properly be made. There also is the Publicity Branch which through press, radio, movies,

and other channels provides Canadians with factual information, including this volume, on the work of the Department.

Then, too, there is the Industrial Security Branch responsible for the maintenance of security and vital projects throughout the Dominion. This branch works in close co-operation with the R.C.M.P. and the Legal Branch.

At one time it was found that plant scrap was not being utilized to the full. As a result, the Scrap Disposal Branch came into being, and has been successful in locating large quantities of scrap and in allocating it immediately to war industry. Another branch was set up to deal with the protection of petroleum reserves.

In May, 1942, a Wartime Administrator of the Port of Halifax was appointed to exercise full control over all activities and operations of that port except those of the armed forces and the R.C.M.P. Later the Administrator's powers were expanded to cover all Atlantic ports and in November, 1943, his powers were further augmented to enable him to take measures to relieve the congestion in the Atlantic ports and the unsatisfactory living conditions resulting therefrom.

The individual units of the Department naturally mushroomed during the early months of the war. Later, an Organization and Personnel Branch was formed to bring conformity on these matters to the individual units of the Department, and at the same time to provide a better liaison with the Civil Service Commission which, at that time, was struggling with the immense problem of rapidly obtaining adequate and competent personnel.

One of the most important branches of the Department, and in many ways one of the most vital, is its Washington office, which came into being on March 14, 1940. Following the fall of France two long cables from London reached Ottawa and New York. They asked for a long list of army ground equipment to replace the terrific losses at Dunkirk. Canada jumped right in to meet these losses. And to this day the volume and variety of her production still reveal the impact of those cables from London.

In July, 1940, meetings were held in New York and Ottawa where the cables to both countries were rolled into one. There it was decided that the weapons required would be produced by whichever country could fill the need in the shortest time. This first meeting made history. It was the first attempt to integrate the war production of Britain, Canada, and the United States. Continuing this process of integration has been the real work of the Washington office.

In the early days the office acted as the Canadian purchasing agency in the United States. Demands poured in on behalf of the three services. Great orders were placed. But there were scarcities. Canada needed transport planes; none could be obtained. However, the Washington officials secured and bought them second-hand. Available aircraft engines were discovered in a Latin-American republic and were promptly purchased. In those urgent days, every avenue of obtaining munitions was explored.

As the flow of munitions from the United States developed, so in course of time the various purchasing units of the Department sent representatives permanently to the Washington office. To co-ordinate the purchasing of U.S. supplies, at the beginning of 1941 was formed the United States Purchases Branch which carries out departmental purchases in that country in conjunction with, and through the Washington office.

At the beginning of 1941 Canada was running short of U.S. dollars. In April, 1941, the President of the United States and the Prime Minister announced the Hyde Park agreement. To implement the Hyde Park agreement, the Department incorporated War Supplies Limited on May 13, 1941, to negotiate and receive orders from departments of the United States government for war supplies to be manufactured in Canada. This company has handled extensive sales to the United States of munitions, metals, and other supplies. But the extent of its activities will only be revealed when the advent of peace permits its one customer to disclose these operations which have often been of a vital character.

Further implementing the Hyde Park agreement was the formation in rapid succession of these joint committees:

Material Co-ordinating Committee

Joint Economic Committee

Joint War Production Committee

More recently was formed the Joint Production and Resources Board on a tripartite basis with Great Britain. Through these committees the Canadian industrial war program is integrated with that of the United States and the United Kingdom.

In the early days of the war perhaps the most acute shortage of all was that of machine tools. Without the efforts of the Washington office to obtain essential tools the Canadian war program would have bogged down. In the three years ending June, 1943, the Washington office procured 40,000 new machine tools for Canada. During this period only 17 machines were refused to this country.

In the procurement of supplies in the United States, Canada has received the utmost consideration. Not only does this obtain in the procurement of munitions and supplies, but also does it obtain in the priorities picture. Of the work of the Washington officials it can be said that much of the co-operation and integration of the industrial efforts of the two countries which now obtain had their inception in the Washington office of Munitions and Supply.

Fulfilling a similarly important and vital function in relation to the United Kingdom is the London office of the Department. Early in 1940 it was recognized that steps should be taken to link more closely munitions operations in Canada with the needs of Britain. In June of that year a suitable representative was found and an office set up in London.

The London office rapidly grew in importance and in the volume of its operations. Throughout it has been a most successful mechanism and one which has

contributed materially to the smooth working relationships between the Department and the various British ministries overseas. Through its operations, the creation and the delivery of munitions to where they were most needed have been materially expedited.

The growth within three years of an organization such as Munitions and Supply from naught but words on the printed page of an Act of Parliament to a staff of 4,500 was not unaccompanied by stresses and strains—both mental and physical. One of the strains was office space which was always at a premium for the lusty war baby. That the Legal Branch had to move 13 times in three and a half years evidences something of the physical problems encountered and surmounted.

Not the least difficult of the problems was that of creating within a year or two an organization competent to handle, not merely the task of providing arms, but also of mobilizing the entire economy of the country. This involved obtaining personnel competent to meet problems far greater than those encountered in private endeavor and of welding them into a smooth-working, co-ordinated unit. In private business long years of endeavor go into creating a properly trained and functioning organization. Under the drive of war, and by that co-operation and goodwill that manifests itself in national emergencies, the Department created an organization which might well be the envy of any private undertaking anywhere.

GENESIS AND GROWTH

IN THESE pages, an effort has been made to outline an amazing story. The industrial output of Canada has been almost tripled in 48 months. New productive facilities equalling in value all the pre-war plants in Ontario have been created. The story covers the greatest use and development of Canadian resources that this land has ever seen. It recounts the struggle of Canada to become a mighty industrial force. It is the story of a miracle. It is the story of Canadian war production.

Back of all this feverish activity, driving, urging, and planning, lay the Department of Munitions and Supply, which was created by Act of Parliament, on September 13, 1939, a few days after Canada declared war. The Department, the Foreign Exchange Control Board, and the Wartime Prices and Trade Board have directed the war economy of Canada. They have done more than that. They have handled all the war problems of the Dominion save those borne by the fighting forces.

That the administrative mechanisms of the war economy set up in September, 1939, have expanded, but have remained basically unchanged throughout the conflict, indicates the soundness of their conception and their subsequent approach to the problems which the war created. Despite the increasing volume of affairs handled by these agencies, administratively they operate on the same basis as four years ago and continue to provide immense supplies of material for Canadian forces, much greater supplies of munitions and raw materials for the Allies, and adequate supplies for the civilian population upon a fair and democratic basis, namely, rationing.

The methods taken to administer the war economy in Canada have not infrequently been envied elsewhere. The contrast between the operations conducted by the Department of Munitions and Supply and those pursued by other countries is startling.

Nowhere else is all the purchasing for the armed forces carried out by one central body. Nowhere else is there an absence of competition between the Army, Navy, and Air Force for supplies. And nowhere else has the body which supplies the three services the power to mobilize industry and resources in order to attain a maximum production.

The story of the growth of the munitions industry in Canada begins before the war when the first few steps were taken to initiate such an industry in this country. The government arsenals were producing small quantities of munitions and had expanded. Some small munitions purchases were also made in Canada and in the United Kingdom.

In August, 1936, the War Office made a contract with the National Steel Car Company in Hamilton for the production of 50,000 25-pounder shells at the rate of 1,000 per week. Prior to the war this contract was enlarged and capital assistance provided for plant expansion.

In 1937-38 contracts for the production of Bren guns were made with the John Inglis Company, Toronto, both by the Canadian and U.K. governments. This plant and, of course, the contracts have been enormously increased.

Towards the end of 1937 the Department of National Defence contracted with the Montreal Construction Supply and Equipment Limited, Montreal, for the establishment of a plant for the manufacture of 18-pounder and 4.5-inch shell. To some extent this plant was on an experimental basis; it was later enlarged and produced a variety of other types of shell.

In November, 1938, the British Air Minister placed two initial orders for aircraft in Canada, one with Canadian Associated Aircraft Limited for 40 Hampden bombers, and one with Canadian Car and Foundry Company for 40 Hurricanes.

Early in August, 1939, the British Ministry of Supply placed an order with Marine Industries, Limited, Sorel,

Quebec, for 100 complete equipments and 200 carriages for 25-pounder guns. Some funds were provided for the expansion of the plant. To fulfill this and subsequent contracts, the company formed a subsidiary named Sorel Industries Limited. This plant also was later largely extended. The contractor guaranteed to the British Ministry of Supply that the French armament firm of Schneider Limited would take care of all the technical aspects of production.

In July, 1939, Canada faced the fact that war was imminent and probable. For some time previously, the government had been expanding its defence activities. But in that month the government determined to take immediate steps to expand as rapidly as possible the production of war materials.

Determined that there should be no recurrence of the profiteering of the last war, on July 14, 1939, the government created the Defence Purchasing Board to make all purchases in excess of $5,000 on behalf of the armed forces. The board was composed of the president of the Canadian National Railways, one of the leading men in the labor movement in Canada, and two outstanding industrialists. Thus, even before the outbreak of hostilities, government war purchasing was placed, not only on a modern basis, but on a basis which, by assuring only a reasonable profit to contractors, received widespread public approval and support.

So successful was the operation of the Defence Purchasing Board that the government extended its powers, and later on September 15, 1939, created the War Supply Board. The new board had much the same personnel as the Defence Purchasing Board, but it also had the power to organize industry for the prosecution of the war; and it placed all contracts for war material both above and below the $5,000 figure. On November 1 the new board took over the functions of its predecessor body.

Meanwhile the Department of Munitions and Supply Act had been passed on September 13 at the second session of Parliament in 1939. But no action to launch

the Department was taken until midnight of April 8-9, 1940, when it came into being and took over the operations of the War Supply Board.

With the creation of the War Supply Board and the passing of the Munitions and Supply Act within a few days of the outbreak of the war, the government took two steps which later observers might suppose involved a measure of duplication. If the decision was taken in September, 1939, to establish a Department of Munitions and Supply, why did the government at the same time establish a War Supply Board with almost identical powers and duties?

The answer lies in the pressure and circumstances of the time. The techniques of purchasing for the armed services were being established and extended. If these techniques were to be transferred at once to a full fledged government department, then in those critical days it would have been necessary to select at once a minister to head the new department. But at that time every minister of the Crown was driven by existing obligations to the very limit of his capacities.

It seemed simpler and wiser, therefore, to delegate for a time the purchasing activities and the preliminary work of mobilizing industry to a well chosen board headed by leading industrialists.

So the War Supply Board came into being to discharge these functions until the government could more fully delineate its war needs and plans. Thus the passing of the act constituted a notice of intention of establishing the department. The powers given to the War Supply Board assured prompt action to meet the immediate needs of the forces and, when appropriate, to continue the organization of the war economy of this country.

By the end of the first quarter of 1940 the government envisaged the end of the sitzkreig and the approach of the holocaust. It realized industry would have to be more rapidly mobilized and contracts placed with greater speed—responsibilities too great to be handled by a board.

So, at midnight on April 8-9 the Department was launched and took over the operations of the War Supply Board. The number of contracts placed in the second quarter of 1940 doubled those of the first quarter. The contracts placed in the third quarter of that year doubled those placed in the second quarter.

While the Department was thus born in April, 1940, the policies pursued and the works accomplished were those envisioned from the very outset. In short, the purchasing methods and the means taken to mobilize Canadian industry and resources have remained unchanged during four years of a conflict in which the Canadian economy, as never before, has been subjected to pressures, strains, and urgencies. That they have remained basically unaltered indicates their administrative soundness, manifests public confidence in the methods pursued, and is the best evidence that production has been attained without profiteering.

Following the launching of the Department, the signs of the coming debacle in France were increasing. These signs and portents placed increasing burdens on the shoulders of the newly organized Department which was called upon, not merely to handle a sharp increase in orders, but also a rapid expansion of its personnel and of the spheres in which it operated.

These twin problems could not be met by the employment of civil servants. First, not enough civil servants were available. And second, those available having an adequate background of experience already were grappling with other and equally important war activities.

The problem of personnel was solved by conscripting experienced executives from across the Dominion, many of whom were in a position to serve without remuneration. While this principle had been followed in a small way by the War Supply Board, the new Department developed and extended this policy. One month after its launching, thirteen prominent executives were serving the Department without salary. At the end of 1943 some 170 so-called dollar-a-year men were serving the Department and its component Crown companies either at their own expense or on loan from their own firms.

With the situation in Europe early in 1940 deteriorating day by day, the Department was throwing dollar-a-year men and other executives, usually specially plucked from private industry, into, for them, the new business of being civil servants.

This is neither the time nor the place in which to discuss the psychological and other effects of hurling a group of business men—many of whom had never before worked for others and many of whom were, to say the least somewhat individualistic—into an organization designed to serve the nation and to operate for the benefit of their fellow Canadians. But from this potpourri of personalities, from this hash of temperaments, did immediately emerge a team determined to do its best by Canada. Despite occasional eruptions of temperament, despite a few early and forgivable misconceptions regarding the relationship between the civil servant, paid or unpaid, and the Crown, it is fitting and proper here to record that in those turbulent days, when freedom seemed to be slipping over the horizon, the dollar-a-year men and the other "conscripted" executives sweated seven days and seven nights a week to provide, as well as within them lay, impetus to the production program and weapons for our arms abroad.

But these men were not alone responsible for the speed with which the plans of the Minister gathered momentum. There were many others, equally competent and experienced, who served as temporary civil servants and administered important programs. The Department benefitted greatly, too, from the experienced advice and strenuous efforts of many competent permanent civil servants.

No less noteworthy and no less valuable was the 90 to a 100 hour week worked by the entire personnel from messenger boy to Minister. They gave their utmost in those now distant days when every minute, every hour counted. Only the future will accurately assess the value, implications, and wisdom of their work; but even now it appears that under the guidance of the Minister they laid the foundations of the industrial future of Canada.

It is difficult in print to recall the spirit of the early months of the Department. The pressure and struggles of those days were reflected, not only in many physical breakdowns amongst the personnel, but also by several deaths. The results on the staff were such that it was necessary to install a medical dispensary and clinic in the Munitions and Supply offices.

During the first eighteen months of war, the government and the Minister had to make sudden decisions involving expenditures of millions. Coastal and other defences were initiated; work began on costly secret plants and projects; and ships, aircraft engines and other equipment were obtained by the Minister often only by oral agreement. The administration of these contracts was then handed over to departmental officials. Not infrequently the lawyers only legally consummated these transactions at a time when the project involved had been completed. Their learned paper work would thus have had an Alice in Wonderland quality had not their final duly sealed, signed, and delivered contracts served to record and crystallize departmental policy and thus set up an invaluable basis for future negotiations.

So under these circumstances between July and September, 1940, inclusive, the value of the contracts placed by the Department were 60 per cent greater than those placed in the preceding ten months.

At its inception the Department consisted solely of a group of purchasing divisions together with a division engaged in seeking and surveying suitable industrial facilities for the production of munitions. But before the end of June, controllers had been appointed to administer the timber, steel, and oil industries. In July, the Metals Controller was appointed and in August the Machine Tool and Power Controls came into existence.

The pressure on the economy occasioned by the purchases of munitions at that time may be judged from the creation of these controls. They were set up, not with the idea of being required at some future date, but because the war demand necessitated immediate conservation or diversion measures.

Similarly, the pressure on the Department necessitated the creation of some mechanism which would permit the broadening of its activities without limiting or retarding its operations. Thus Citadel Merchandising Co. Limited, the first company in Canada to be owned by the Crown, was incorporated in May, 1940, to administer and improve the critical machine tools situation. So, in June, Federal Aircraft Limited was incorporated, and in July, Research Enterprises Limited was born. In August, Small Arms Limited and Allied War Supplies Corporation also came into being.

Thus in the first four months of its infancy, the Department had not only laid out its future course, but had already widely developed all those administrative and productive mechanisms which continued to mark its operations in ensuing years.

By the end of 1940 other Crown companies came into existence and new controls were created. And following informal meetings of the controllers, to integrate their programs came the creation of the Wartime Industries Control Board. Similarly, following meetings of those heading the production branches, the Production Committee was formed in 1941; in 1942 the Production Committee became the Production Board. Thus the Department early assumed a shape and form which was to remain basically unchanged despite the later expansion of its activities.

During these early days and indeed up to 1943, requisitions from Canadian forces and from the United Kingdom poured into the Department which, often at a moment's notice, had to find or create production sources for a chemical, a gun, or a plane.

Nor was it always easy to obtain the more mundane supplies such as clothing, shoes, and other personal equipment, the demand for which often involved the immediate doubling or tripling of production by several firms.

At one time in 1941 the armed forces were expanding so rapidly that the Canadian knife and fork manufacturers temporarily could not meet the demand. To tide

over the situation, departmental purchasing agents bought supplies of knives and forks from wholesalers' stocks across the country. Even some large retailers' stocks were acquired. The result of this step taken under the duress of the moment was a widespread crop of rumors indicating that the Department was no longer buying from the producer but purchasing at a higher cost from middlemen.

In the early days there was a real danger of enemy attack, particularly on the coasts. At that time the Department was called upon to take many steps which had no apparent connection with the war. On more than one occasion private citizens on both coasts were subjected to public censure for steps which they had taken at the secret request of the Department but regarding which the complete story cannot yet be told.

Not the least of the more serious problems the Department had to face, not only at its inception but for many months thereafter, was keeping up with the amazing demands, the amazing growth of the Air Training Plan. Providing 200 airports and their hangars alone was a task. More difficult was the provision of planes and engines at a time when Britain could not meet her expected deliveries to Canada of the aircraft and engines required under the plan and at a time when the United States had also joined the scramble for airpower. In one day the Minister arranged the purchase of aircraft engines to the extent of $15 million; and it was this and other purchases which permitted the Air Training Plan to expand without one day's delay in its appointed schedule.

It was a similar story with tanks, guns, ammunition, mines, ships, explosives, instruments, and all the other specialized equipment required by the soldier, sailor, and airman, for which Canada had little or no experience or capacity.

It is not without significance—and perhaps post-war significance—that Canadian plants not only learned how to make these products but in many instances improved substantially on the long-established methods and processes employed elsewhere.

Early in 1941, in order that all supplies for the Army should be under one department, the arsenals officers of the Department of National Defence were transferred to the Department of Munitions and Supply—a trend which was to continue some months later with a similar transfer of the signals and design engineers from National Defence. Thus on the shoulders of the new Department rested the entire responsibility for meeting the requirements of the armed forces.

In the first 18 months of its existence, expansion was rapid, indeed tumultuous. The situation is best noted in the expansion of its personnel which numbered 325 on March 31, 1940, and by the end of the year had quadrupled to a total of 1,195. At the end of 1941 the staff numbered 2,864, by the middle of 1942 the total was 4,337—a figure from which it has varied little since.

The early months were a period of development, a period of violent demand for supplies, a period of rapid industrial construction, a period which later brought forth munitions fruit one hundred fold.

Supposedly the entry of Russia into the conflict would have eased the pressure somewhat. Actually no such thing occurred. While the early light of dawn has now dissipated the fog of terrors and fears of yesteryear, in the middle of 1941 it was the consensus that the German attack on Russia would give harassed Britain but a breathing spell of a few months, after which the whole barbarous fury of the enemy would be unleashed on the British Isles.

So the summer of 1941 was industrially even more fast and furious than that of 1940. Hundreds of new plants coming into production were encountering all the headaches and heartaches which accompany that process. Nevertheless they did produce. And at the close of 1941 on the day after Pearl Harbor, the United States was grateful to be able to rush planes across the border to obtain guns made in Canadian factories, guns which were vital for U.S. defence.

During 1941 the already substantial production of chemicals, explosives, and motor vehicles was largely

augmented. The Dominion was also producing cargo ships, corvettes, minesweepers, and smaller supplementary Naval craft. Aircraft production was also mounting rapidly. In the field of guns, production was well established. Being produced were 25-pounders, Bofors, 3.7 ack ack, together with a wide variety of tank and anti-tank guns, machine guns, and small arms. Production of small arms and heavy ammunition was extensive and was forging upward. Cruiser and infantry tanks were in production, and the volume of miscellaneous supplies, ranging from wireless equipment to armor plate and from radiolocators to searchlights, was extensive.

The year 1942 witnessed a great flowering of production, which was later tied into that of the United States through the activities of the Joint War Production Board which has a Canadian and U.S. membership. The operations of this board were later co-ordinated to the needs of the United Kingdom by means of the Combined Production and Resources Board, which represents the United Kingdom, the United States, and Canada.

The year 1942 also witnessed the bringing into production of virtually all types of munitions and supplies. It was a time of violently expanding production which culminated in the peak production of 1943 when, towards the end of the year, were increasingly witnessed those revisions in the production program made necessary by the changing pattern of the war abroad.

In 1943 the increased production level of the Dominion was such that under the Mutual Aid Plan the flow of supplies to Russia and to China was increased. The activities and the productive effort of this year in which Canada reached what may prove to be the peak of her productive effort are summarized in the first chapter of this volume.

As a result of the efforts of the Department, in four years the Dominion has undergone an industrial transformation which, under normal circumstances, could not have taken place in twenty-five years. Some $800 million has been expended on hundreds of new plants and facilities, and thousands of new machines owned by the

Crown. In addition, some peacetime industries have expanded to five and even ten times their former size.

While a tremendous amount of purchasing and preliminary work was carried out by the two predecessor purchasing bodies, the vast wartime expansion of the Dominion only really commenced with the launching of the Department in April, 1940. In June, 1940, the Department was called upon to replace equipment abandoned on the beaches of Dunkirk. So, starting with this, Britain's darkest hour, the story of industrial expansion in Canada falls into these four periods:

1940—Planning, organization, and development.

1941—Plant construction and beginning of substantial production.

1942—Bringing virtually all munitions and supplies into production and increasing output.

1943—Peak production with revisions necessary according to the changing needs of war.

The tabulations at the end of this volume reveal the growth and results achieved during the four-year period in which this country converted and developed her industries to the point where her manpower and her machines constituted a bastion of freedom. The dull figures speak only in mathematical terms and even to the seeing eye reveal naught of the struggles on a hundred production fronts to provide materials for ships, tanks, planes, mines, guns, vehicles, explosives, and shells. The story of these battles for production cannot be covered chronologically. They all took place at the same time. And so the story of Munitions and Supply becomes the series of stories developed in the preceding chapters.

Lacking herein, also, is any measure of the sweat of hundreds of thousands of men and women who in four years helped to turn Canada into a vast arsenal and geared its economy to meet an enemy of human freedom, ruthless in method, huge in power, and fortified by years of preparation. Such matters can only be sensed between the lines of this record; but when the victory shall have been won, they may perhaps be set forth by other, better, and more leisured hands.

APPENDIX

The facts and figures in this appendix highlight some of the operations of the Department and of its two predecessor boards which were responsible for purchasing on behalf of the armed forces during the first seven months of the war.

Value of Contracts Awarded

Including Government financed plant expansion to December 31, 1943

x Contracts placed, Canadian Account	$4,907,911,478
x Contracts placed, U.K. Account	3,226,716,838
Contracts placed, other Accounts	1,285,366,989
Contracts placed by the Civil Aviation Division (Department of Transport) on behalf of the Air Training Plan for airfield construction (est.)	50,012,000
Total (a)	$9,470,007,305

(a) This figure excludes letters of intention and unvalued acceptances of tender.

x Includes contracts awarded under the Air Training Plan, some of which are chargeable to other Empire countries.

Value of Contracts Awarded

Canadian Account Only

	Value of Contracts	Cumulative Value of Contracts
1939	$ 64,798,487	$ 64,798,487
1940	786,215,173	851,013,660
1941	1,101,205,578	1,952,219,238
1942	1,524,280,952	3,476,500,190
1943	1,431,411,288	4,907,911,478

These figures represent contracts awarded on Canadian Account exclusive of letters of intention and unvalued acceptances of tender. Also excluded are orders placed by the Department of Transport on behalf of the Air Training Plan.

Total Number of Contracts Awarded

All Accounts

1939	Third quarter	147
	Fourth quarter	4,279
1940	First quarter	5,801
	Second quarter	12,436
	Third quarter	25,573
	Fourth quarter	27,041
1941	First quarter	25,164
	Second quarter	41,671
	Third quarter	47,446
	Fourth quarter	54,081
1942	First quarter	52,955
	Second quarter	65,205
	Third quarter	71,715
	Fourth quarter	70,139
1943	First quarter	68,266
	Second quarter	71,237
	Third quarter	64,416
	Fourth quarter	59,413
Total to December 31, 1943		766,985

Number of Contracts Awarded

Canadian Account Only

Let by the Defence Purchasing Board and the War Supply Board, July 14, 1939, to April 8, 1940	11,136
Let by the Department of Munitions and Supply, April 9, 1940, to December 31, 1943	729,558
Total number of contracts awarded	740,694

Dates of Establishment of Controls

Timber Controller	June 24, 1940
Steel Controller	June 24, 1940
Oil Controller	June 28, 1940
Metals Controller	July 15, 1940
Machine Tools Controller	August 22, 1940
Power Controller	August 23, 1940
Ship Construction and Repair Controller	November 27, 1940*
Motor Vehicle Controller	February 13, 1941
Chemicals Controller	July 10, 1941
Transit Controller	August 12, 1941
Supplies Controller	August 19, 1941
Construction Controller	August 26, 1941
Aircraft Controller	June 25, 1942
Rubber Controller	November 3, 1942‡
Coal Controller	March 5, 1943†
Wood Fuel Controller	May 28, 1943†

*In April, 1941, the powers of the Controller of Ship Construction and Repair were amended and he became the Controller of Ship Repairs. In May, 1942, the powers of the Controller of Ship Repairs were again amended and he became the Controller of Ship Repairs and Salvage.

†On October 18, 1939, a Coal Administrator was appointed to act under the Wartime Prices and Trade Board. The Administrator also had jurisdiction over wood fuel. In March, 1943, jurisdiction over coal, coke, and wood fuel passed from the Board to the Department of Munitions and Supply. In May, 1943, a separate Wood Fuel Control was created.

‡Before the establishment of Rubber Control, rubber was under the jurisdiction of the Supplies Control.

Note: The Transport Controller, although acting jointly with the foregoing as a member of the Wartime Industries Control Board, is attached to the Department of Transport. His control, which he exercises under that Department, covers railway facilities and the movements of all government supplies; it includes priorities on vessels operating from Canadian ports and in Canadian waters.

Quarterly Tabulation of Personnel

in the Department of Munitions and Supply and Predecessor Boards

Date	Number
July 18, 1939	3
November 1, 1939	164
December 31, 1939	200
March 31, 1940	325
June 30, 1940	500
September 30, 1940	850
December 31, 1940	1,195
June 30, 1941	1,492
December 31, 1941	2,864
June 30, 1942	4,337
December 31, 1942	4,724
June 30, 1943	4,918
December 31, 1943	4,560

Canada's Iron and Steel Production

(in long tons)

Year	Pig Iron	Ferro-Alloys	Steel Ingots and Castings
1913	1,008,006	7,210	1,043,744
1914	699,254	6,718	739,858
1915	815,871	9,638	911,414
1916	1,043,979	25,556	1,275,222
1917	1,045,071	38,808	1,558,691
1918	1,067,456	39,914	1,672,954
1919	819,447	43,394	919,948
1920	973,568	27,781	1,100,622
1921	593,829	22,608	667,484
1922	382,967	21,602	480,127
1923	879,822	41,887	881,523
1924	593,049	35,034	659,767
1925	570,766	25,709	752,503
1926	757,317	57,050	776,262
1927	709,697	56,230	907,945
1928	1,037,727	44,482	1,234,719
1929	1,080,160	89,116	1,378,024
1930	747,178	65,223	1,009,578
1931	420,038	46,764	672,109
1932	144,130	16,161	339,346
1933	227,317	30,133	409,979
1934	404,995	31,921	757,782
1935	599,875	56,616	941,527
1936	678,231	76,284	1,115,779
1937	898,855	82,072	1,402,882
1938	705,427	55,926	1,155,190
1939	755,731	76,375	1,383,262
1940	1,168,839	133,387	2,015,447
1941	1,364,336	182,459	2,411,888
1942	1,773,337	186,608	2,787,067
1943*	1,610,000	194,800	2,708,000

* Estimated.

Non-Ferrous Metals

COMPARISON OF WORLD PRODUCTION AND CANADIAN PRODUCTION

1939 1942

(In thousands of short tons)

	1939 World Prod.	1939 Can. Prod.	1939 % of World	1942 World Prod. (Est.)	1942 Can. Prod.	1942 % of World
Aluminum (Refined) ..	749	83	11.1	1,496	336	22.4
Index	100	100	...	199	405	...
Copper (Blister)	2,354	254	10.8	3,045	275	9.0
Index	100	100	...	...	...	...
Lead (All Forms)	1,899	196	10.3	1,884	251	13.3
Index	100	100	...	99	...	...
Nickel (All Forms) ...	137	113	82.3	171	142	83.0
Index	100	100	...	...	125	...
Zinc (Refined)	1,850	176	9.5	2,316	216	9.3
Index	100	100	...	125	...	...
Total	6,989	822	11.8	8,912	1,220	13.7
	100	100	...	...	...	...

Estimated Value of War Production

Program	1939-40	1941	1942	1943	Total
	(Millions of dollars)				
Aircraft (including overhaul)	45	110	232	368	755
Armored Fighting Vehicles (including tanks)	...	21	155	218	394
Mechanical Transport	119	198	368	429	1,114
Cargo and Naval Vessels (including repair)	27	102	256	421	806
Chemicals and Explosives (including ammunition filling)	2	54	136	151	343
Guns and Small Arms	1	20	157	199	377
Gun Ammunition (including bombs)	14	95	218	193	520
Small Arms Ammunition	2	16	39	74	131
Instruments and Signals	3	15	82	164	264
Miscellaneous Military Stores (including clothing, personal equipment, foodstuffs, fuel, etc.)	97	181	412	521	1,211
Total	310	812	2,055	2,738	5,915
Defence Construction and certain other construction let by the Department of Munitions and Supply	94	138	219	194	645
*Plant expansion, government financed (including machinery and equipment)	112	255	210	222	799
Total	516	1,205	2,484	3,154	7,359
Deliveries on orders placed abroad	60	104	140	322	626
Grand Totals	576	1,309	2,624	3,476	7,985

NOTE: These figures cover only war production and construction on orders placed by the Department of Munitions and Supply. Deliveries of war exports placed through other government and private agencies are excluded.

*These figures include approximately $63 million of contracts negotiated by the United Kingdom Technical Mission which are not included in the chapter, "Construction."

Canadian War Production

	1940x	1941	1942	1943	Total
Aircraft—Number produced	904	1,699	3,781	4,133	10,517
Weight in short tons, without engines	870	2,179	8,789	10,044	21,882
Vehicles—Mechanical transport	70,000	119,000	192,000	175,000	556,000
Armored vehicles and tanks	0	3,000	12,500	15,500	31,000
	70,000	122,000	204,500	190,500	587,000
Guns—Barrels, carriages, and mountings numbered as separate units	150	7,000	31,000	45,000	83,150
Small Arms—including machine guns	1,400	27,000	325,000	580,000	933,400
Heavy Ammunition and Projectiles—Complete rounds, filled	0	1,200,000	28,000,000	30,000,000	59,200,000
Plus: Empty cartridge cases for export xx	958,000	4,455,000	15,025,000	18,323,000	38,761,000
Empty shells for export xx	0	3,000	1,356,750	887,000	2,246,750
Small Arms Ammunition—millions of rounds	112	390	1,200	1,500	3,202
Chemicals and Explosives—net output in tons	13,500	145,000	430,000	500,000	1,088,500
Shipbuilding: xxx					
Cargo Vessels—Number	0	1	81	150	232
Tonnage	0	10,350	838,350	1,478,000	2,326,700
Naval Vessels and Patrol Boats	16	123	117	100	356
Other Vessels and special purpose craft	0	0	35	447	482
Instruments and Communications Equipment	$ 3,000,000	$ 14,800,000	$ 82,000,000	$164,000,000	$264,000,000

x Includes last four months of 1939.

xx In addition, cartridge cases and other ammunition components have been produced and filled for export as components.

xxx In addition, to end of 1943 a total of 345 small craft with power, and 3,199 small craft without power, were produced.

Purchasing Principles

The various purchasing principles, policies and methods employed by the Department since its inception are outlined in the following paragraphs from an instruction letter to the negotiating officers and purchasing agents of the Department:

In years to come the danger and the emergency will probably be forgotten and the accomplishments in building up, in a few short months, a great productive mechanism will be accepted as a matter of course. It may well happen that we shall then be judged by the measure of success we have achieved in seeing that the Canadian people received the best possible value for the money spent by us on their behalf.

Maximum value for the taxpayer depends on getting the manufacturers of the country to produce at

(a) highest possible efficiency
and

(b) distinctly moderate profit margins.

It is essential that we be concerned with both of these factors. Of the two, however, manufacturing efficiency is by far the more important, because not only does it mean high output of desperately needed munitions and supplies but it is concerned with the bottom 90-95 per cent of the price, while profit is ordinarily the upper 5-10 per cent. The easy course is to concentrate on control of profit margins and allow the costs to take care of themselves as, for instance, by use of the cost-plus-percentage contract form. The difficult and correct course in the national interest is to proceed so that contractors will feel vitally concerned in driving their costs down, with all the energy, initiative and ingenuity of their peacetime activities, and yet ask no excessive return for themselves.

Manufacturers will not argue the desirability of high efficiency and low costs. They should not argue that the benefits of such efficiency should not be passed along to the government, in major degree at all events. This should be clear because:

(1) A substantial part of Canadian war production is sold to other countries on the distinct understanding that the prices contain no more than a modest profit margin before income tax charges.

(2) The monetary return for services rendered the nation at a time of grave peril and severe financial strain must be of modest character equally for the soldier, the wage earner, the official and the manufacturer. The national conscience will not tolerate inordinate charges from anyone.

(3) In times of peace, cost reductions find their way to the consumer sooner or later, in great part, if not in toto. Much more should this be so in time of war, when it is the great volume of government orders which in large measure makes possible cost-reducing efficiencies, and when it is the people as a whole who pay the price.

(4) Low profit margins are not a hardship to the manufacturer because the war orders he receives are usually so large in relation to his normal activities that he can work on one-third or even one-quarter of his usual spread and still have an ample return on capital.

Cost reduction is often a difficult thing, involving long and anxious study, strong determination, ingenuity in economizing, and moral toughness above the ordinary. It cannot be invoked alone by a contract in which the profit motive is stressed. Patriotic desire to make a worthy contribution and interest in the job for the sake of the job, are equally important influences, to name only two. Yet, in the final analysis, the character of the contractual arrangements with the manufacturer can have a vital bearing on the way in which he performs, and we must therefore be concerned at all times to see that, as far as humanly possible, we do set up our contracts in such a form that the profit motive is present as a medium and incentive to cost reductions for our benefit.

CONTRACT TYPES

It will be obvious at first sight that two types of contract fail to accomplish the twin objectives of low costs and profit control, namely:

Cost-plus-percentage, in which the urge is towards higher cost as a means to higher profit.

The long term, prematurely negotiated, fixed-price contract, in which the contractor has every incentive to cost reduction but keeps the resultant profit for himself.

These are the Scylla and Charybdis—the rocks of disaster—between which we must steer.

The contract types which serve our purposes most effectively are those which provide:

Fixed prices for moderate quantities of stores at any one time, following genuinely competitive tenders.

Fixed prices for moderate quantities at a time, based on engineering or accounting pre-costings.

Fixed prices for moderate quantities at a time, based on audited costs of trial production runs.

Audited costs, plus a unit fee, plus a bonus for cost reduction or early delivery.

Audited costs, plus a fixed unit fee.

The principal points to be observed are:

Fixed price contracts should be for a few months at a time only and repeat contracts should be on a constantly descending scale of prices. Thus the contractor keeps any additional profit he may make in each period through his ingenuity in driving down his costs, but is required to pass along to the government in the succeeding period, the benefits of such cost-reducing activities.

Competition must be aggressive and keen and it is our responsibility to keep it so. Collusion in bidding must be driven out.

Fixed prices based on pre-costings can be very deceptive unless a real knowledge of the contractor's actual overhead exists. Therefore, such arrangements should usually apply to smaller contracts only—say $50,000 or under.

Audited costs of trial production runs have proved an excellent starting point for a succession of contracts at constantly declining prices. These are most effective when set up on a target basis, and are ideal where the total quantity to be made is large, where competition cannot be invoked and where design changes are infrequent.

The audited cost, plus unit fee, plus bonus plan is ideal for larger items such as guns, gun mountings, airplanes, ships, etc., provided the design changes are not so material or frequent as to be incapable of pricing as extras and provided enough cost data exists to set a reasonably safe base for bonus.

The audited cost, plus a fixed unit fee plan carries no direct incentive for cost reduction It does, however, carry incentive for speed of output. Speed of output may be the vital need at any cost but speed of output can usually be obtained only by organization and efficiency which increase the man-hour output of the individual machine and worker and thus in the long run reduce costs. This scheme is peculiarly suitable to larger items which are subject to design changes.

Contract types which do not serve our fundamental purposes but which have to be used sometimes are:

Cost-plus-a-percentage-on-cost.

Cost plus a fixed fee if the cost does not exceed a named amount, plus an increased fee if the work does exceed that amount.

Ceiling price—audit adjustment.

The last two are variations of the cost-plus-percentage scheme and are open to the same basic weaknesses.

Cost plus a percentage on cost is justified only where there is a great diversity of small items, as in the case of spare parts for airplanes, guns and tanks. For reasons of expediency only, it is necessary that such items should be bought on a cost-plus percentage basis.

Cost plus a set fee for a designated job, subject to increase if the cost of job increases, is justified only where adequate plans and specifications of the job do not exist and it is necessary, for reasons of urgency, to get the work under way and provide complete plans and specifications as the work proceeds. The additional unit fee is intended to take care of additional work not contemplated in the original scheme. Such arrangements should be limited to contractors of the highest character, but should be subject to specially close supervision on the job, and the unit fee should be of steadily diminishing character so as to minimize any tendency on the part of the contractor to "spread out" or increase the job. Here again expediency and emergency of compelling character can be the only justification.

The ceiling-price audit-adjustment contract has a certain amount of merit where the price set as the ceiling has been the subject of careful investigation and keen negotiation and provided there is good reason to believe that it does not include any undue margin of profit. However, while under this contract form the manufacturer must be concerned to see that his costs are within his estimate, there is no great incentive for him to make special efforts to get his costs down, particularly if the percentage of profit on cost has been agreed to in advance. If a ceiling price arrangement must be used, it should be on the basis that the profit is to be fair and reasonable at the Minister's discretion, after the job has been completed. Here, at least, the manufacturer has some incentive for cost reduction, because if it can be demonstrated that he really has done something extraordinary in the way of efficiency or other excellent performance, he may justifiably expect to receive a larger percentage of profit. Unfortunately, however, such demonstration is extremely difficult in practice.

If a contractor, in bidding on a job, has reason to believe that his price will be accepted as a ceiling he is likely to load his cost estimates with contingencies and, having obtained the job on such a basis, he will exert himself very little to achieve cost reduction. Indeed, he has now succeeded in getting a safe cost-plus percentage contract with the additional advantage that he may receive "progress" and other payments from the government based on the full ceiling price and thus have the benefit of any excess over his true cost for the financing of his business in general. This excess might easily run into substantial figures.

PROFIT MARGINS

An impression has unfortunately gained credence in some quarters that all our buying should be on the basis of a 5 per cent profit margin. It is true that 5 per cent is the focal point, but slavish adherence to this margin can defeat every purpose of intelligent purchasing policy. In many cases 5 per cent

is much too high, particularly in large contracts where the productive facilities and finance are provided by the government. It may also be much too high where the item under manufacture is of simple character and the manufacturing cycle short in time, as in the case of some types of textiles. On the other hand, 5 per cent may be unduly low in the case of highly technical stores in which the manufacturing cycle is long and the output small in relation to contractor-provided facilities, with current financing at contractor expense. Moreover, special service in matters of design, delivery, assistance to other contractors, engineering, etc., warrant consideration. The rate of profit on the small order, which involves any considerable machine set-up, should naturally be higher than that allowed on the larger order. There must be no thought on the part of anyone, however, that large profit margins can be allowed. A range running from 1 per cent to 10 per cent should meet every normal situation.

It must always be remembered, however, that our task is maximum value for the taxpayer's money and that there has been, and can be again, a situation in which one contractor, operating under an incentive scheme, has supplied an article at a total cost of $4,200 with a 12 per cent profit to him, while another contractor on a cost-plus scheme, has supplied an article of identical quality, quantity and delivery at $5,200 with a 3 per cent profit to himself.

TAXATION

It is to be borne in mind always that our responsibility is with fair and reasonable prices, not with the profit which remains with the contractor after payment of taxes. Our concern is with costs and rates of profit margin on costs, not with net profits on contractor's investment.

The incidence of excess profits taxation is such that many contractors claim the incentive has been removed from their business. This ought not to be true, because the taxation on standard profit is far from confiscatory and the post-war refund on their excess profits can easily be substantial. Apart from this the freedom of the nation should be enough incentive.

In point of fact, however, the urge to show good profits is so great in the majority of manufacturers that in most cases it is a marked exaggeration to contend that the weight of taxation destroys initiative and incentive for cost reduction. In the latter connection, any contractor, who expects to survive during the post-war period, knows very well that efficiency and low costs now are of the utmost importance.

RENEGOTIATION

If the foregoing policies could be applied uniformly and successfully there would be no need for renegotiating contracts. Under conditions of urgency, however, it is inevitable that transactions will be agreed upon from time to time based on what turn out to be miscalculations of costs. This usually occurs through the application of normal rates of overhead on labor to a greatly super-normal volume of production. It is inherent in the purchasing policy of nations at war that the fruits of such miscalculations, from whatever cause, should not be retained by the contractor. Hence, in the United States, in England and in Canada, the governments have the power to reopen contracts in which they have reason to feel that the profit margins are exceptional. Contractors usually urge that renegotiation should be done on the basis of their year-end statement and on the average of their various contracts. We cannot admit this as a principle. It enables waste and inefficiency on one contract to be covered up by excess profits on another. It detracts from the incentives to cost reduction since the higher the cost the less the likelihood of the necessity for renegotiation being discovered. Apart from this, it stands in the way of our being able to demonstrate to the United States, or other nations who purchase war supplies from us, that the profits on individual contracts have been properly controlled.

COST AUDITS

Under sound purchasing policies, cost audits will be used principally for establishing bases for price negotiations and for policing purposes. Such audits have particular applicability to sub-contracts in cost-plus prime contracts, where the prime contractors either care less than we do about the expenditure of

government funds or are able to accomplish less by reason of their more limited powers. The constant and continuous use of audits, except in cases where the cost-plus method is inescapable, are an evidence of weakness in negotiating. This applies particularly to the acceptance of contractor's quotations without investigation on a ceiling-price, audit-adjustment basis. Moreover, limitations of staff will only result in a congestion of auditing of small items and greatly lessen the effectiveness of the audit staff in respect of those items in which auditing is essential. The objective of the purchasing agent should be to buy soundly without resort to cost audits. On the other hand, where the contractor stubbornly holds out for prices which the purchasing agent cannot justify to himself as sound, or where co-operation and frankness in disclosure of costs cannot be secured, there can be no alternative to a demand that the costs be audited by the Treasury cost accountants.

These Treasury accountants have accumulated a wealth of information as to costs and as to the overhead rates which should prevail in various types of industry, and purchasing officers will find co-operation with them to be of great value.

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